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Welsh Birds

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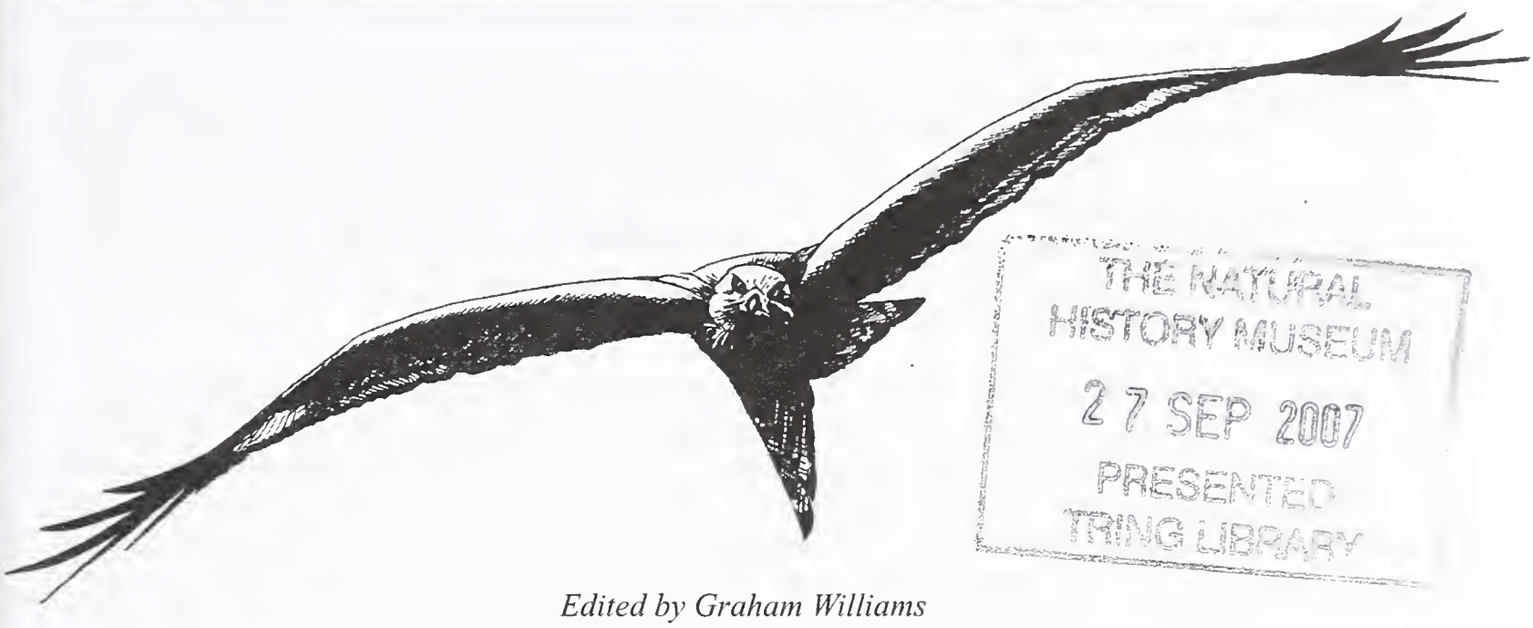

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Edited by Graham Williams

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Text illustrations by Bob Mitchell, Colin Richards and Steve Roberts

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EDITORIAL

This issue, my last as Editor, is slightly later than usual, for which I apologise. This is due, in part, to my wish to include in this number some very recent work which has only just been written up whilst, at the other extreme, taking the opportunity to publish valuable research from the 1960s which has not previously appeared in print but which has some important contemporary messages for bird conservation.

I particularly welcome the opportunity to include the paper on the status of Common Scoter in Welsh waters and Liverpool Bay, 2001-2006, which details the findings of the All Wales Common Scoter Survey which started in 2000/2001 and which has made a very significant contribution to our knowledge of waterbirds using nearshore marine waters. This survey revealed the presence of Common Scoter numbers which greatly exceed previous estimates of wintering numbers in the whole of Great Britain and, amongst other conservation successes, provided the data which largely led to the designation of Carmarthen Bay as the UK's first marine Special Protection Area.

It is also a pleasure to include two further papers on an emblematic Welsh species, the Raven. Julian Driver's paper on breeding performance in Snowdonia is the result of an outstanding amount of fieldwork and is set against a backdrop of a rapidly increasing population and resultant reduction in distances between nests. By contrast the backdrop of the situation on the Gower is one of a relatively stable population, albeit one which has shown a marked shift away from coastal sites. The authors of the Gower paper have made full use of the availability of comprehensive data preserved in Museums from two egg collectors active on the peninsula from the 1930s, which has enabled interesting comparisons to be made with the present day.

In view of recent concerns about the implications of cockling on the Traeth Lafan it is very timely to place on record the research carried out there by Peter Dare and his colleagues on the Oystercatcher population in the 1960s when there was no commercial cockle fishing. The findings highlight, amongst other points, that the whole of Liverpool Bay needs to be treated as having a meta-population of Oystercatchers, confirming that it is important from a conservation point of view not to look at one site in isolation.

Work on the diet of Little Owls on Skomer confirmed that Storm Petrels are an important part of their diet in the summer months. This makes me wonder if Little Owls also prey on the tiny population of Storm Petrels on Bardsey?

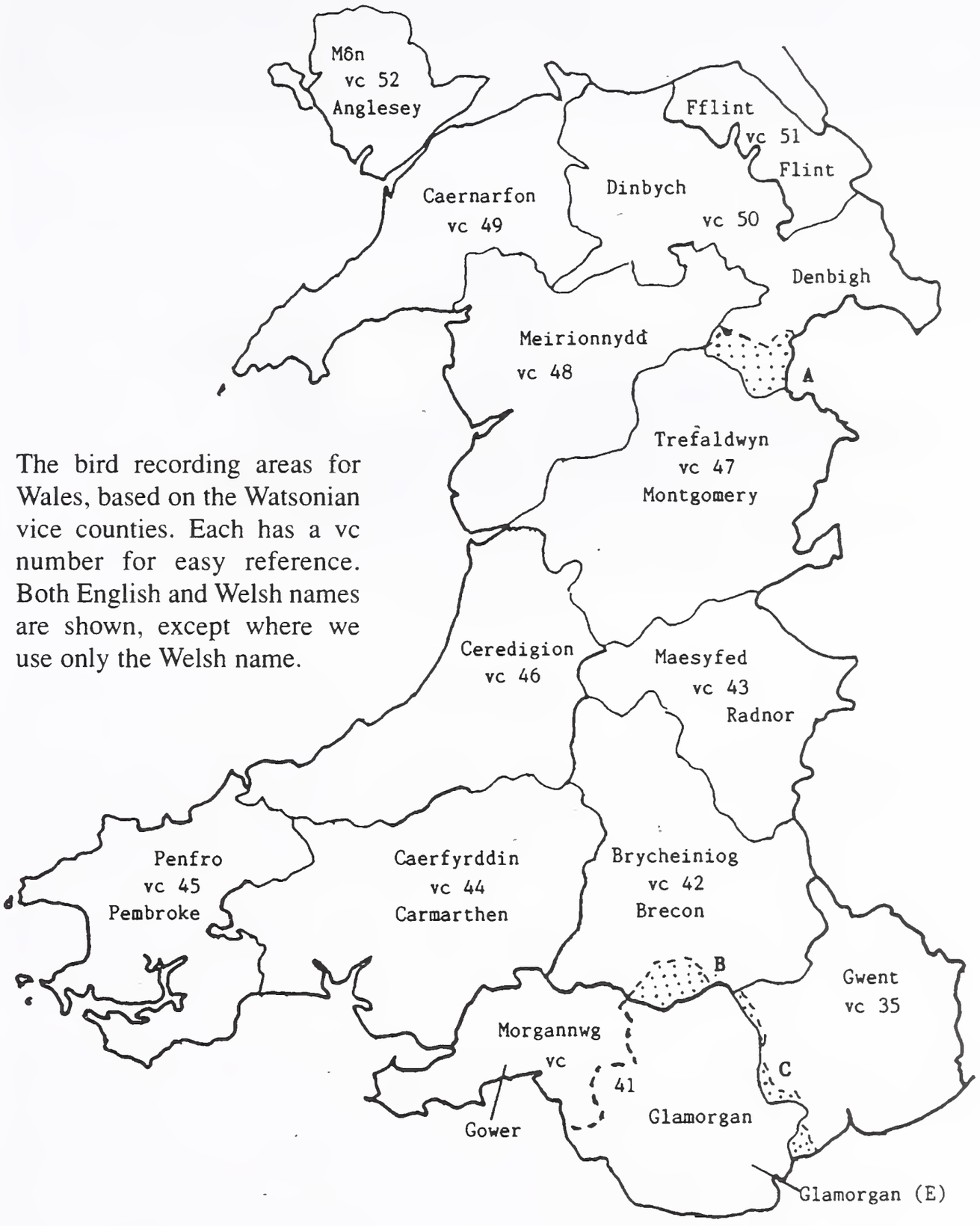
On a disappointing, but not unexpected, note two 2006 surveys showed that there are continuing marked declines in the Welsh breeding populations of Curlews and Ring Ouzels, the former probably as a result of poor breeding success and the latter due to a combination of factors, possibly including climate change. To end on a more positive note, as one should as an outgoing Editor (!), it is good to note that the recent recovery in the Black Grouse population has been largely maintained (although there are still concerns about range reduction) and that research on Nightjars, which are at their highest recorded level in Wales, has thrown up useful information on their requirements.

ACKNOWLEDGEMENTS

My very grateful thanks to Kev Joynes for allowing me to use his splendid photograph of a Black Redstart at Llanwrthwl for the front cover and for, as ever, the wonderful support of Bob Mitchell, Colin Richards and Steve Roberts in providing vignettes. I am also greatly indebted to the referees for their helpful comments : Mike Shrubb, Ivor Rees, David Allen, Julian Driver and Andrew Dixon.

Finally, I take this opportunity to pay tribute to my predecessor as Editor, Mike Shrubb, for his unfailing assistance, advice and bonhomie throughout my term and I am delighted that Stephanie Tyler has agreed to put her name forward as my successor in the happy knowledge that the journal will be in extremely capable and dedicated hands.

The Bird Recording Areas in Wales



The bird recording areas for Wales, based on the Watsonian vice counties. Each has a vc number for easy reference. Both English and Welsh names are shown, except where we use only the Welsh name.

THE STATUS OF COMMON SCOTER *Melanitta nigra* IN WELSH WATERS AND LIVERPOOL BAY, 2001 - 2006

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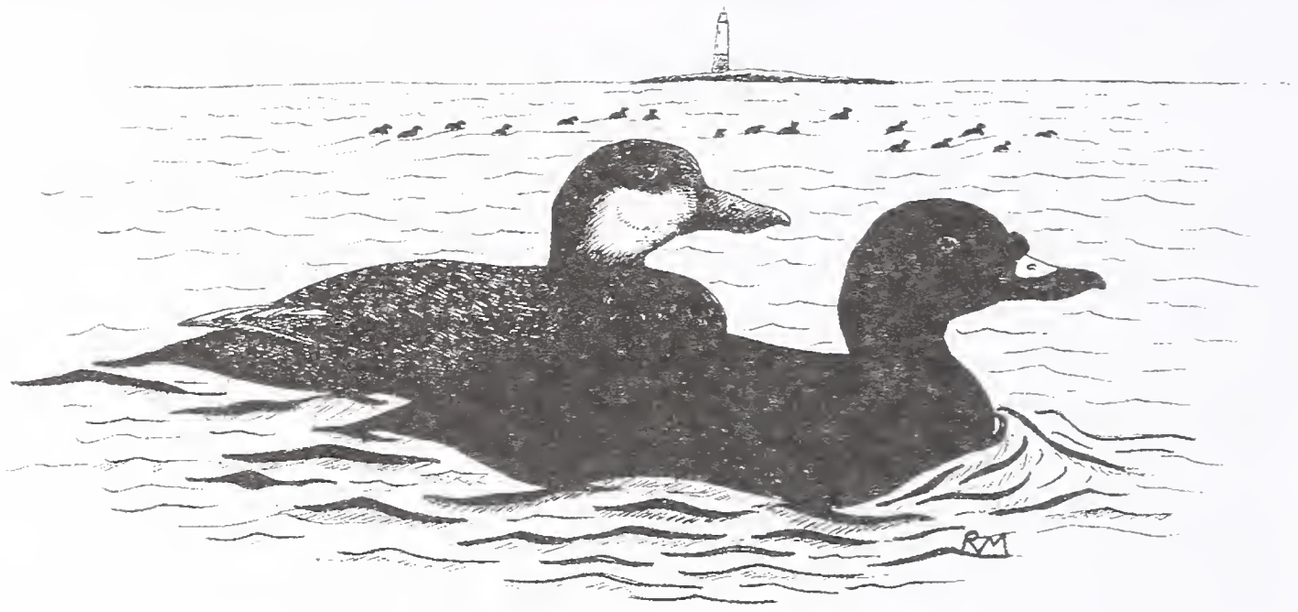


SUMMARY

The All Wales Common Scoter Survey (AWCSS) is a programme of land-based and aerial surveys started in 2000/01. It aims to provide accurate information on the numbers and distribution of Common Scoters *Melanitta nigra* and other waterbirds using nearshore marine waters, particularly to enable the identification and designation of Special Protection Areas (SPAs) under the EC Birds Directive, to assess the potential impact of proposed offshore windfarms, and to inform the UK Common Scoter Biodiversity Action Plan. Between 2001/02 and 2005/06, aerial surveys were undertaken using a 'distance sampling' approach that has enabled statistically robust estimates of numbers, and accurate data on the fine-scale distribution of birds, to be produced.

The AWCSS and complementary survey programmes have greatly improved our knowledge of the status and distribution of wintering Common Scoters, and have provided the first comprehensive assessment of the major resorts in Welsh waters and Liverpool Bay. Surveys revealed the presence of considerable numbers during winter months, with peak means of 51,400 scoters in Liverpool Bay, 8,100 in Cardigan Bay and 20,200 in Carmarthen Bay over the five-year period. An all-Wales total of 40,000 - 50,000 Common Scoters is suggested, with a further 20,000 - 25,000 off the English coastline of Liverpool Bay, though an additional 20,000 - 30,000 birds have on occasion occurred in Liverpool Bay as a whole. Such numbers greatly exceed previous estimates of wintering numbers in the whole of Great Britain. This is thought to reflect the availability of better data, rather than a genuine increase in numbers.

Large numbers of Common Scoters were found over Shell Flat, a shallow sandbank that extends west from Blackpool. Previously unknown to support scoters, at least 20,000 are regularly present during winter, with a peak of around 50,000 in February 2003, making this the most important site for this species in the UK. The AWCSS also revealed that scoters are regularly found at considerable distances - up to 20 km - from shore where suitable conditions allow, notably over Shell Flat and the sandbanks in Cardigan Bay where waters are less than 10 m deep. Prior to the aerial survey programme, it was thought that scoters in British waters were restricted to areas close to land. These findings dictate that aerial surveys are required for continued monitoring of these sites and this species.

Large numbers of Common Scoters were consistently present at the key resorts during the five winters, with no obvious trend over the period. Peak numbers occurred in late winter, usually in January or February, in Carmarthen and Liverpool Bays, though insufficient data are available to determine a pattern in Cardigan Bay. There are gradual changes in distribution during the course of a winter, presumably in relation to food depletion in shallower areas. There is a noticeably different distribution in spring in Liverpool Bay, with a shift to areas less favoured during winter, though the reasons for this are unclear. Small but notable numbers are present at all three major resorts in late summer, when circumstantial evidence suggests that birds are moulting at these sites.

The AWCSS has also delivered several notable conservation successes. Carmarthen Bay was designated as the UK's first marine SPA, because of its importance for Common Scoters, principally using AWCSS data. Aerial survey data have also assisted the consent process for offshore windfarms in Liverpool Bay, helping to minimise the effect of installations upon birds, and, through re-siting three farms proposed for Shell Flat, have been instrumental in safeguarding the premier site in the UK for this most sensitive of seaducks.

INTRODUCTION

The sandy coastal bays of Wales have long been known for their large numbers of Common Scoters *Melanitta nigra*. In particular, some 20,000 are regularly found in Carmarthen Bay during the winter months, and this has traditionally been considered the UK's most important site for the species (Kirby *et al* 1993, Lovegrove *et al* 1994, Pollitt *et al* 2003). But this seaduck is difficult to survey because its large flocks often stretch several kilometres from shore. Birds are frequently found at such distances that, even with the most powerful telescopes, glare, heat haze or the slightest of swells renders accurate counting an almost impossible task.

Actual numbers of Common Scoters in Carmarthen Bay were poorly known until the early 1970s. Counts from several vantage points around the bay had suggested between 2000 and 3000 birds (Sutcliffe 1975, Moyse & Thomas 1977). But observations by the RAF from a boat positioned four miles off Pendine in early 1973 counted some 8000, while readings from the radar indicated at least a further 12,000 to be present. This inspired Roger Lovegrove of RSPB to conduct an aerial survey, during which some 10,000 scoters were counted. Assuming that declines in numbers over the previous few weeks in nearby St Brides Bay would be mirrored in Carmarthen Bay as birds departed their winter quarters, 20,000 were again thought to be present. A boat-based count three miles offshore in mid March 1974 estimated 25,000, and the significance of Carmarthen Bay for Common Scoters, both as an internationally important site and as the premier UK location for the species, was firmly established (Sutcliffe 1975).

Further aerial surveys and ground-based counts were made during the 1970s, recording in excess of 10,000 scoters on a number of occasions, including 10,600 in July 1976 and 12,000 in July 1978 (Lovegrove *et al* 1994). Fewer observations were made during the 1980s, but aerial

surveys and more comprehensive land-based counts in the early 1990s again recorded large numbers, with around 18,000 in December 1992 (Lovegrove *et al* 1994, Cranswick *et al* 1998). In 1994, the Countryside Council for Wales (CCW) instigated a programme of land-based and aerial surveys. Some 17,650 were counted from land in December 1994 (Stewart 1996), but aerial surveys at this time used a 'concentric' flight path within the bay (see 'Aerial survey methods'; figure 1), designed to provide an 'index' of numbers rather than a complete count. Thus, although it was known that Carmarthen Bay continued to be of importance for scoters, and that large numbers occurred in late summer and late winter, the rather *ad hoc* nature of the counts, made using a variety of methods, meant that a definitive assessment of numbers, phenology and distribution was not possible.

The *Sea Empress* oil spill changed all that. The stricken tanker ran aground in Milford Haven on 15 February 1996, spilling 72,000 tonnes of crude oil. Some 15,000 tonnes entered Carmarthen Bay seven days later (Law & Kelly 2004), killing an estimated 4600 Common Scoters (Hughes *et al* 1997). Accurate counts became a necessity, to assess the spill's impact on Common Scoters and the bay, and CCW consequently commissioned ground and aerial surveys in 1996/97. Peter Cranswick of WWT was invited to join the aerial survey team, and the methods were revised, adopting a series of parallel transects to provide both full coverage of the bay and a fine-scale picture of distribution, previously lacking for offshore areas (Cranswick *et al* 1998). Two PhD studies were also established, funded by CCW, to assess the numbers and distribution of Common Scoters, and to determine the invertebrate fauna, particularly those species which were likely to be eaten by scoters. Over the next three winters, an intensive programme of land-based and aerial surveys was undertaken by Lucy Smith, providing the first comprehensive assessment of the year-round use of Carmarthen Bay by Common Scoters. This showed that numbers had recovered quickly after the spill, with winter counts (November to March) regularly exceeding 15,000, and a late-winter peak ranging between 18,200 and 22,000 (Woolmer *et al* 2001, Banks *et al* submitted).

Surveys of the UK's small breeding population of Common Scoters in the mid 1990s showed a continuing decline in numbers and range (Underhill *et al* 1998). The species was consequently included in the UK Red List (Gibbons *et al* 1996), and a UK Biodiversity Action Plan (BAP) was drawn up. The BAP targets include the need to maintain the range and distribution of both moulting and wintering Common Scoters.

Two growing issues at that time also dictated the need for more accurate and detailed information on the numbers and distribution of birds using nearshore marine waters. The demand for greater use of 'renewable' energy saw the expansion of the UK's windfarm industry into marine sites, and the requirement, under the EC Birds Directive, to designate important sites for birds as Special Protection Areas (SPAs) was extended to fully marine areas.

From the late 1990s, the shallow waters off north Wales and northwest England became the subject of intense interest for proposed windfarms. These areas were also known to be important for Common Scoters - large concentrations were regularly reported in the early 20th century (Lovegrove *et al* 1994), while land-based counts showed sizeable numbers were present in the early 1990s, particularly in Colwyn Bay (Kirby *et al* 1993) - although, as with Carmarthen Bay, accurate data were lacking. Consequently, Siân Whitehead of CCW assembled a group of interested parties, consisting of several NGOs (including WWT, Lancashire Wildlife Trust and Liverpool Bay Wader Study Group), statutory conservation agencies, the Crown Estate and energy companies. A project was subsequently commissioned to provide data on the numbers and distribution of Common Scoters in Liverpool Bay to inform the various needs and the UK Common Scoter BAP.

Aerial surveys were undertaken in 2000/01 to provide the first comprehensive coverage of Liverpool Bay. Four flights during winter months were made by Peter Cranswick and Lucy Smith, using the same methods as in Carmarthen Bay. In February 2001, a survey was also undertaken of the northern half of Cardigan Bay, the remaining Welsh site known to support large numbers of Common Scoters (Kirby *et al* 1993, Lovegrove *et al* 1994). This constituted the first co-ordinated survey of all the major resorts for Common Scoter in Welsh waters and so the All Wales Common Scoter Survey (AWCSS) was born.

The increasing use of aerial surveys both in the UK and in Europe to assess the environmental impact of proposed windfarm developments had prompted the National Environmental Research Institute (NERI), Denmark, to pioneer new aerial survey methods. Consequently, WWT staff visited NERI to review the 'distance sampling' techniques being used for aerial survey in Denmark (see 'Aerial survey methods'). Although analytical methods to maximise the utility of these data were - and still are - in development, confident that the more statistically robust results and more precise distributional data afforded by these methods would provide the detailed information needed in relation to SPAs and windfarms, this technique was adopted for the AWCSS and subsequently by others undertaking aerial survey in the UK.

Aerial surveys in Welsh waters have continued since 2001/02 under a number of initiatives, including the AWCSS, principally serving the needs of the windfarm industry, the requirement to identify important areas for birds for designation as SPAs, and to inform the Common Scoter BAP (WWT Wetlands Advisory Service 2003, Cranswick *et al* 2004, Hall *et al* 2005). Surveys in Carmarthen Bay have continued, funded by CCW and undertaken by BTO, both to monitor Common Scoter numbers and to devise standard monitoring protocols for marine SPAs (Banks *et al* 2004). The largest component since 2004/05, led by the Department of Trade and Industry, covers the strategic development areas in Round 2 of the UK's offshore windfarm development programme, and includes most nearshore waters between Anglesey and the Solway Firth (DTI 2006). This paper assesses the numbers and distribution of Common Scoters in Welsh waters and Liverpool Bay using data from 'distance sampling' aerial surveys made between 2001/02 and 2005/06.

AERIAL SURVEY METHODS

Aerial survey methods have evolved over time. A small high-winged plane, usually a four- or six-seater, is flown as slowly as is safe. The single-engined planes used until the mid 1990s operated at about 80 - 90 knots (170 kmh^{-1}); the survey speed for twin-engined planes used since then is around 100 - 110 knots (200 kmh^{-1}). Two observers, each viewing one side of the plane, aim to count all scoters seen. By and large, it is possible to observe and count scoters up to 500 - 1000 m from the plane, though this depends on the conditions (particularly seastate and the amount of glare reflected by the sea) and the numbers of scoters and their aggregations - groups of 2 - 3 birds are, naturally, more difficult to detect than flocks of 100 (large flocks may even be observed more than 1000 m from the plane under favourable conditions). Binoculars are not used to avoid bias but are, in any case, impractical for counting during aerial survey.

The original surveys of Carmarthen, in the 1970s, used parallel transects, approximately 1 km apart. Tracking roughly north - south and flying at a height of around 500 ft (c150m), the survey covered all waters in the bay between Tenby and Worms Head. When surveys were resumed in 1994/95, a concentric route was used (figure 1). Successive passes of the flight path were, however, some 2 - 3 km separate, meaning that birds in the intervening areas were missed, and the survey aimed only to provide an 'index' of numbers. In 1997/98 transects were reinstated (figure 2). These were 1 km apart, with the aim of providing a 'total count' (birds beyond 500 m

from the plane were not included in count totals). Numbers of scoters recorded were summed for each 2 km flown - these points identified by a navigator using a Global Positioning System (GPS) - to provide a grid pattern of distribution. This method, similar to that described by Komdeur *et al* (1992), was employed throughout the intensive three-year study of Carmarthen (though a twin-engined plane was then used in preference to a single-engine) and also for surveys of Liverpool and Cardigan Bays in 2000/01.

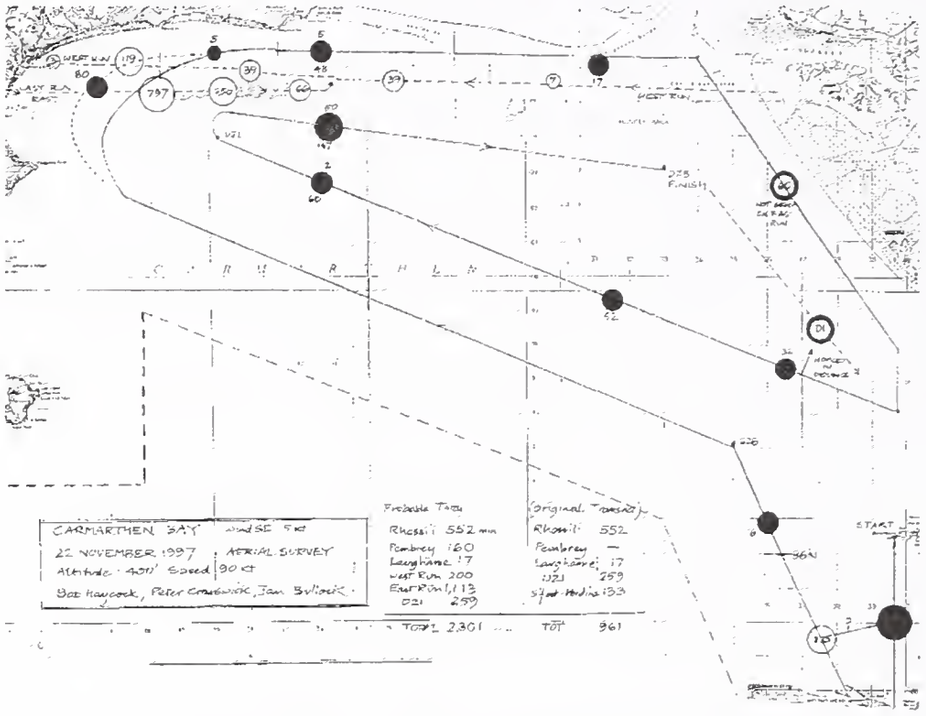


Figure 1. Aerial survey of Carmarthen Bay using the 'concentric' survey method.
The flight path is indicated by the solid line. The locations of scoter flocks are indicated by circles with numbers of birds counted given alongside.

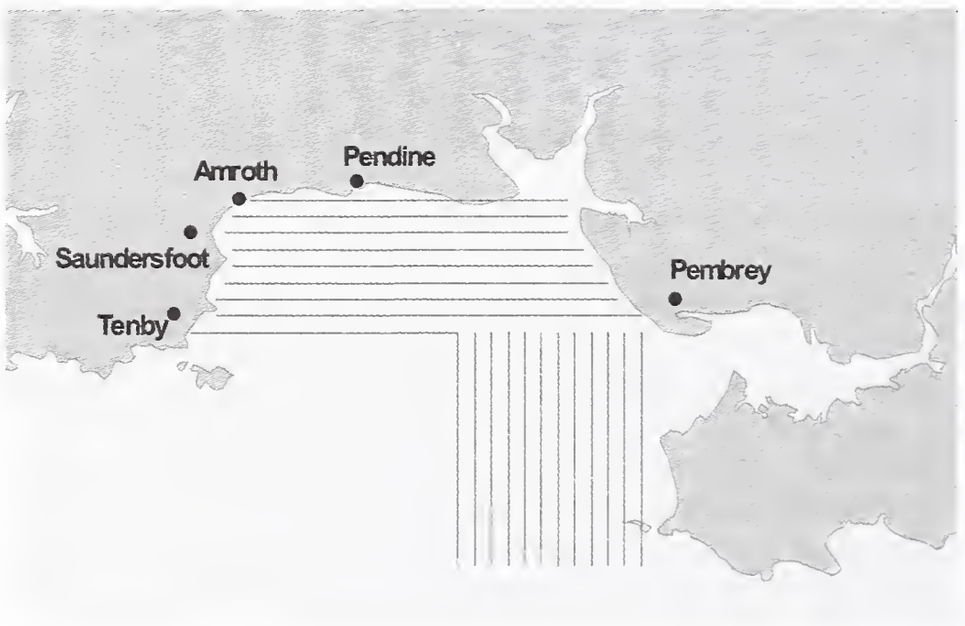


Figure 2. Transects used in Carmarthen Bay for the 'total count' aerial survey method.

From 2001/02, the AWCSS adopted the 'distance sampling' approach developed in Denmark (Kahlert *et al* 2000), which was then also taken up by others conducting aerial survey in the UK for SPA identification (*eg* Dean *et al* 2004), and subsequently endorsed as the standard for windfarm environmental impact assessment (Camphuysen *et al* 2004). Surveys were flown at an altitude of 250 ft (76 m), a height felt to minimise the disturbance of scoters (Common

Scoters are particularly prone to flushing in front of the plane). Transects were spaced 2 km apart, to avoid double-counting (it was felt that flushed scoters generally settled within 1 km of their original location). For each bird or flock of birds, the species, number, behaviour, distance from the plane and time (to the nearest second) at which it was perpendicular to the plane were recorded. Distance from the plane was recorded by noting in which of four distance bands the bird was observed (figure 3). This recognises that birds further from the plane are more likely to be missed and, having recorded the distance to each bird or flock, a measure of the ability of the observer to detect birds can be determined, and an allowance for the birds missed can be used in estimating the total numbers present.

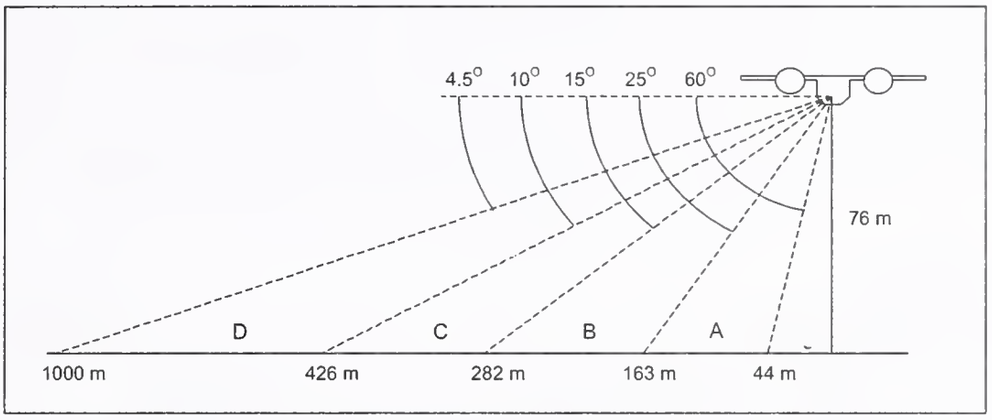


Figure 3. Distance bands used for the 'distance sampling' aerial survey method. *The distances are assessed by the observers using a clinometer, measuring the angles shown below the horizon. Just three distance bands were used during 2001/02 and 2002/03 (when bands B and C were treated as one band).*

Transects were oriented north - south to minimise the glare, and in most areas met the ideal design of being perpendicular to the major environmental gradients (normally, perpendicular to shore, to run across changing water depth). Surveys lasted for a maximum of four hours, and were centred around midday, again to minimise glare.

SURVEY AREAS

Land and aerial surveys in Carmarthen Bay during the 1990s had shown that scoters occur up to 8 km offshore, a distribution linked primarily to shallow areas, with most birds found in water less than 10 m deep (Stewart 1996, Cranswick *et al* 1998). The first surveys in Liverpool Bay, in 2000/01, thus generally targeted the 10 km nearest to shore, between Red Wharf Bay, Anglesey, and the southern edge of Morecambe Bay. Flights off the coast of Blackpool in November and December found large numbers up to the offshore limit of the survey area and so this was extended further west in January. But that survey still did not reach the end of their distribution, and the February flight thus ran 20 km offshore, to cover the waters over Shell Flat - a sand bank that runs due west of Blackpool - less than 10 m deep. Some 11,700 Common Scoters were counted during that flight (Oliver *et al* 2001), one of the largest aerial counts made in the UK at that time, and all the more remarkable given that this area was included in the survey programme because of proposed windfarm developments in that area, rather than an expectation that scoters were present.

With the switch to 'distance sampling' methods, a much larger area could be covered in a single flight (since each transect involved counting a 2-km, rather than 1-km, strip). The areas covered in Liverpool Bay were thus enlarged in 2001/02, generally extending 20 - 30 km from shore, to cover both the full extent of Common Scoter distribution and that of other nearshore waterbirds, *eg* divers, that were by then included in the survey programme. Based on previous land-based

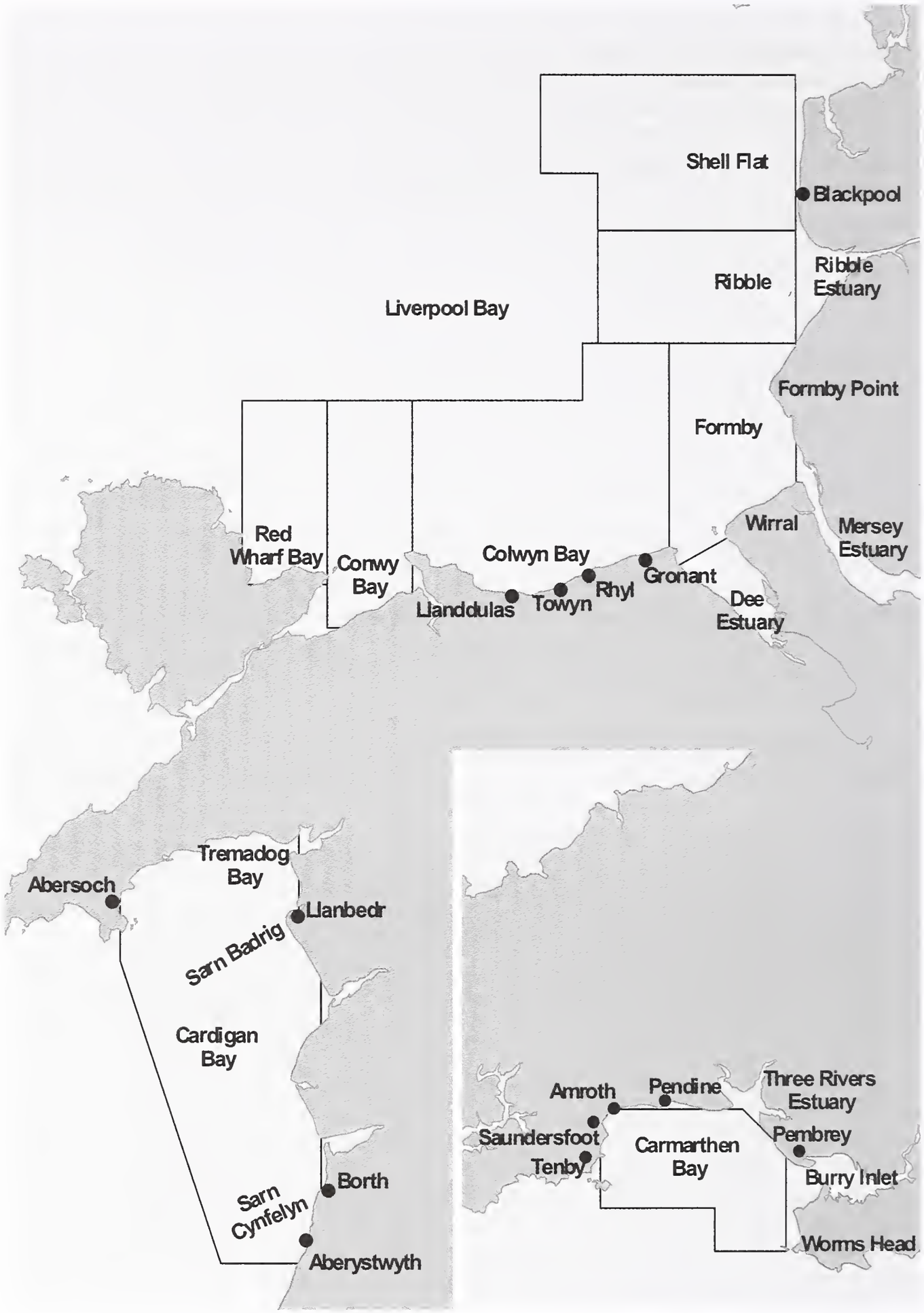


Figure 4. Survey area for the All Wales Common Scoter Survey.
Lines represent the approximate extent of the surveyed area. The locations of place names and features mentioned in the text are also given.

and aerial surveys, the northern half of Cardigan Bay - particularly the western part of Tremadog Bay - was known to support large numbers of scoters (Lovegrove *et al* 1994). Flights thus covered the area north of Aberystwyth and west to Abersoch, to include the shallow sandbanks or 'sarns' that run southwest from the coast at Llanbedr and Aberystwyth. Aerial survey in Carmarthen Bay covered waters up to 10 km from shore, encompassing all waters less than 10 m deep between Tenby and Worms Head (see figure 4 for the principal locations used in this paper to describe scoter distribution).

ANALYSIS AND MAP PRODUCTION

The precise location of each bird or flock was calculated by linking the time at which they were encountered to the location of the plane, recorded every five seconds using a GPS. Interpolating the GPS data enabled the position of the plane to be calculated at each second, with the position of the birds then placed either side of the plane roughly in the middle of the relevant distance band (figure 5). The location of most observations is considered to be accurate to within 200 - 300 m.

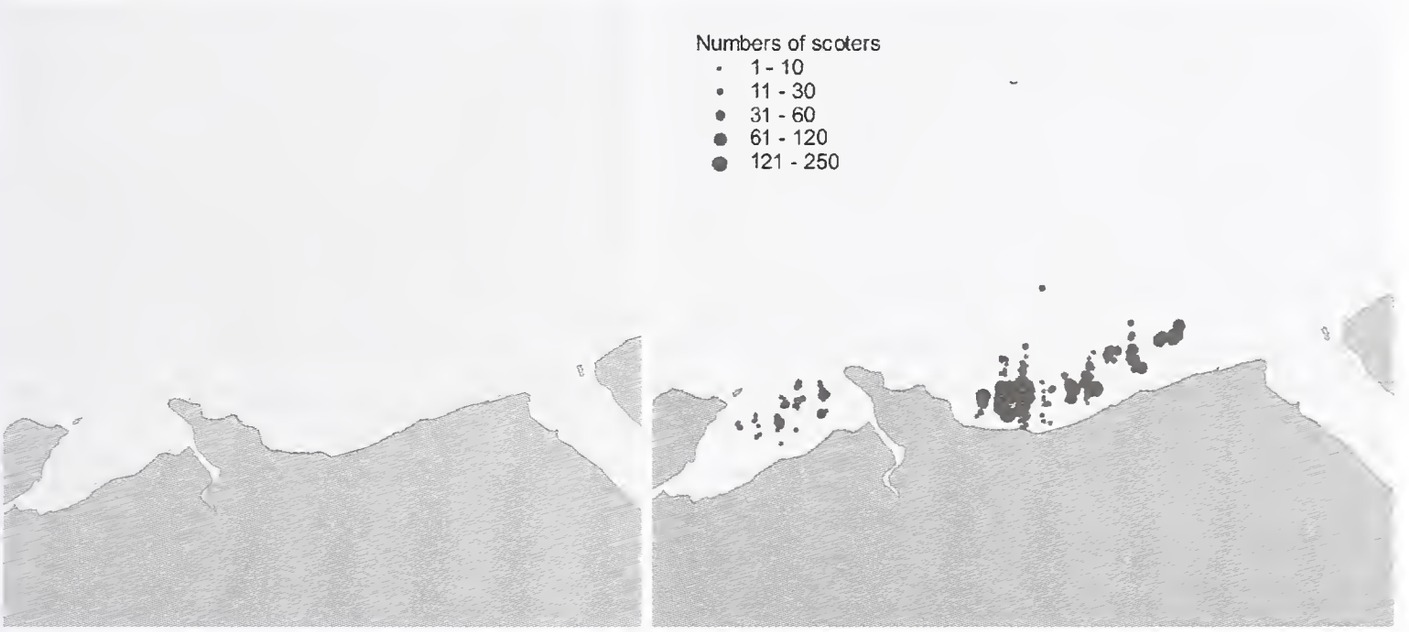


Figure 5. Data from aerial survey of Colwyn Bay on 16 February 2005.
The flight path of the plane is shown by a dotted line, indicating its position every five seconds, as recorded by a GPS. Common Scoter observations are plotted, as described in the text. Although data suggest that birds are distributed in parallel lines, this is an artefact of the detection of fewer birds at greater distances from the plane.

Distribution maps show the encounter rate for Common Scoters using 2×2 km squares. For each grid cell, the numbers of birds counted were summed, and then corrected for survey effort (the distance flown over which observers were actively looking for birds). Casual observations of birds during the turns between transects (when observers are unable to employ 'distance sampling' techniques because the plane is not in level flight) have been omitted from the analysis. The categories of relative density used in the distribution maps are standardised for all maps. It should be noted, however, that although detection rates will have been broadly similar overall, small variations will have occurred during and between surveys owing to changes in visibility and the different abilities of observers. Nevertheless, the patterns shown by the maps are believed to be representative. Distribution maps are presented for different survey periods (table 1) to demonstrate variation in numbers and distribution during the course of a year.

Table 1. Survey periods used for mapping distribution

Survey period	Description	Dates
1	Late summer	27 Jun - 3 Sep
2	Autumn	17 Oct - 20 Nov
3	Early winter	21 Nov - 31 Dec
4	Mid winter	1 Jan - 12 Feb
5	Late winter	13 Feb - 27 Mar
6	Spring	10 Apr - 18 May

Estimates of Common Scoter numbers were calculated using *Distance* software (Thomas *et al* 2005). Where available, estimates from previously published reports have been used (*eg* Hall *et al* 2005, Webb *et al* 2006a), but figures for the most recent winters have been calculated for the first time and, in a number of cases, estimates for earlier surveys have been calculated anew (*eg* to exclude birds observed outside the described survey area). To accommodate the tendency of scoters to flush away from the flight path in response to the plane, estimates were calculated using strip transect methods where appropriate. In some instances, however, the requirements for this approach were not met, in which case half-normal distribution functions with cosine adjustments were found to provide more robust alternatives. No improvements in model fit were obtained by including observer as a covariate and thus it was unnecessary to include this in the models. Data were post-stratified by flock size to improve precision, and 95% confidence intervals were obtained by bootstrap simulation. In general, the estimates of Common Scoters present are around three times greater than the numbers counted by the observers. Numbers of scoters referred to in this paper are estimates calculated using 'distance methods', rather than actual counts recorded by observers, unless specifically noted otherwise.

At least two flights are needed to cover all key aggregations of Common Scoters in Liverpool Bay, and the data are then combined to produce overall estimates. In most cases, flights were made within 4 - 5 days of one another, and it is possible that birds were double-counted or missed if they moved between survey areas in the intervening time. Variation in the extent of survey meant that not all areas of Liverpool Bay were covered in some periods. Where a notable area for scoters (such as Conwy Bay or Formby) was missed, the estimate has been considered an undercount. If several notable areas, or a significant part of either Colwyn Bay or Shell Flat, were omitted, the figure has been classed as a considerable undercount. The extent and amount of survey effort over the five years is shown in figure 6.

NUMBERS OF COMMON SCOTERS

Aerial surveys of the main resorts for Common Scoters in Welsh waters and off the English coastline of Liverpool Bay revealed the presence of considerable numbers during winter months (figure 7). Estimates for Liverpool Bay exceeded 40,000 in all but one winter during 2001/02 to 2005/06, those for Carmarthen Bay regularly surpassed 10,000, and at least 5,000 have been estimated for the three winters in which surveys were made of Cardigan. Although large counts in Carmarthen, Cardigan and Colwyn Bays have been recorded previously from land, counts of this magnitude had only been made on a handful of occasions prior to the mid 1990s. Aerial surveys show that such numbers are present on a consistent basis.

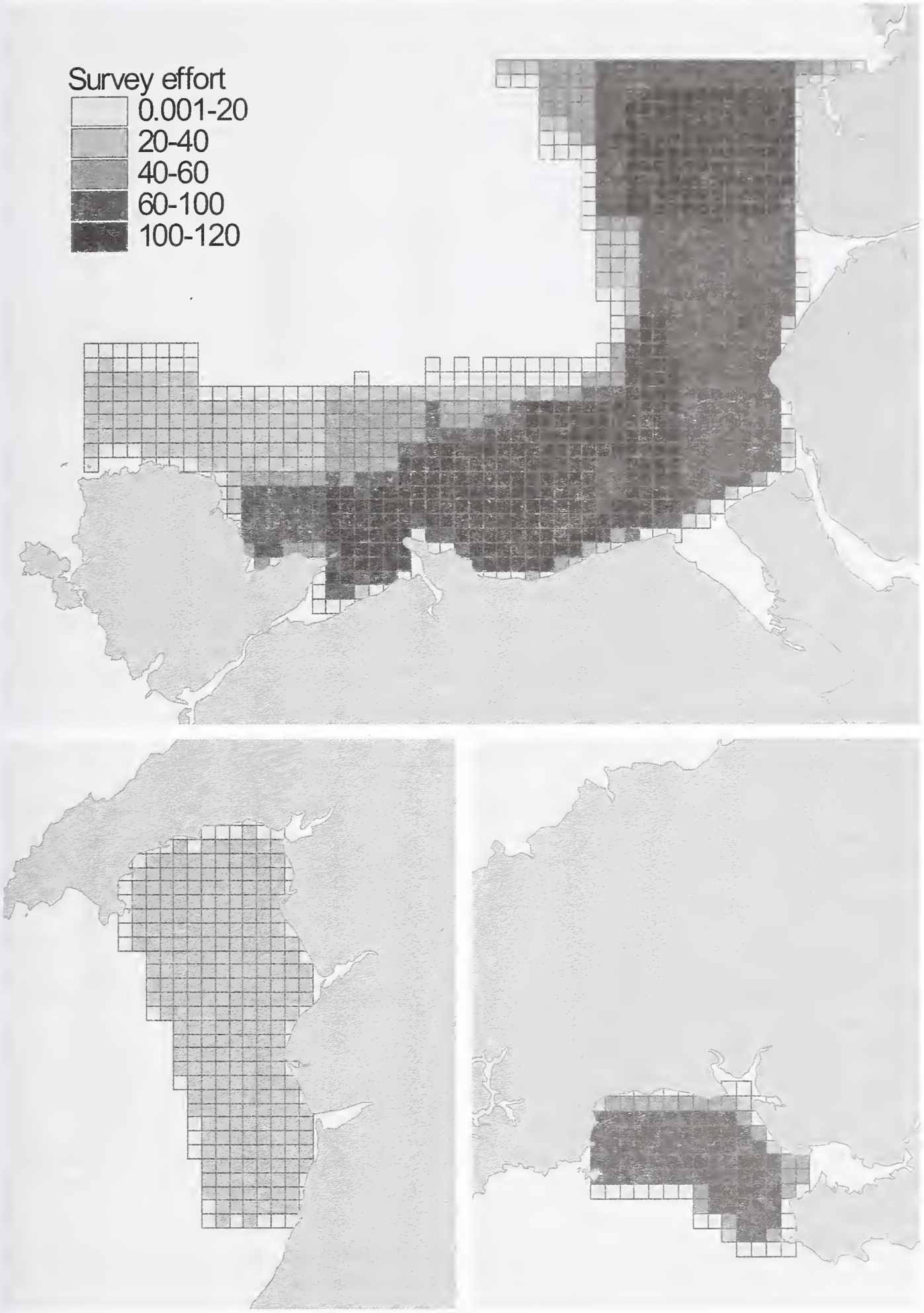
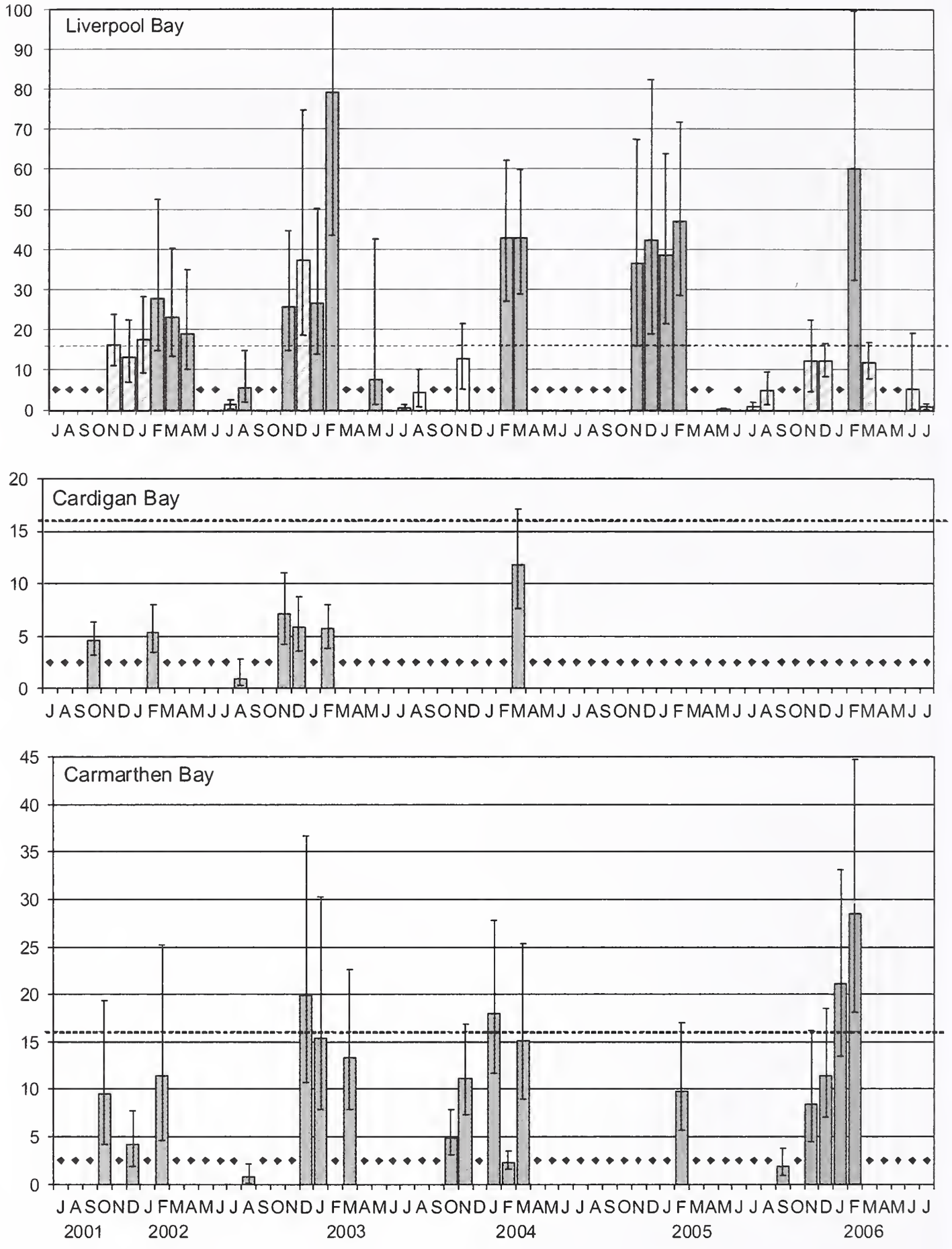


Figure 6. Aerial survey coverage by the All Wales Common Scoter Survey, 2001/02 to 2005/06. *Survey effort is the distance in kilometres over which observers were actively looking for birds, summed by 2 × 2 km grid cells for all surveys.*


Liverpool Bay
100
90
80
70
60
50
40
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20
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0
J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J
Cardigan Bay
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Carmarthen Bay
45
40
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J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J
2001
2002
2003
2004
2005
2006

Figure 7. Estimates of Common Scoter numbers in Liverpool, Cardigan and Carmarthen Bays, 2001/02 to 2005/06 *Estimates were calculated using 'distance' methods. Numbers are given in thousands. Solid grey bars indicate complete counts, hatched bars indicate undercounts, and white bars considerable undercounts (see text). Error bars show upper and lower 95% confidence intervals. (The upper confidence interval for Liverpool Bay in February 2003 is 143,740). Diamonds indicate no count was made. The dotted line shows the 1% international threshold (16,000). Note the different scale for Liverpool Bay.*

The counts from Liverpool Bay as a whole are unprecedented. The peaks of 79,100 in February 2003 and 60,200 in February 2006 considerably exceed not only previous counts for the site, but also the previous estimates for Great Britain as whole. The national total in the mid 1990s was thought to be 27,500 (recalculated from Kirby *et al* 1993), and even a revision in the late 1990s, in the light of improved data - but before extensive aerial surveys - suggested this figure to be only 50,000 (Cranswick in press).

Table 2. Peak estimates of Common Scoters from aerial surveys, 2001/02 to 2005/06
Asterisks indicate counts obtained by land-based surveys of Carmarthen Bay.

	2001/02	2002/03	2003/04	2004/05	2005/06	Mean
Liverpool Bay	27,772	79,136	42,920	46,882	60,215	51,385
Cardigan Bay	5,293	7,125	11,771	-	-	8,063
Carmarthen Bay	20,078*	23,288*	17,999	11,100*	28,456	20,184

On the basis of peak counts from the most recent five winters (table 2), both Liverpool and Carmarthen Bays are of international importance for Common Scoters, as their means comfortably exceed one per cent of the biogeographical population, *ie* 16,000 birds (Wetlands International 2006). Whilst it should be noted that the confidence intervals for these peak estimates are large (figure 7), the lower confidence values for the peaks in Liverpool Bay surpassed 16,000 in all but one year, giving considerable confidence that internationally important numbers of scoters are regularly present.

Although peak estimates from aerial surveys of Carmarthen Bay have exceeded the 1% threshold in only three of the winters, land-based counts at the site have repeatedly recorded in excess of 20,000 birds (Woolmer *et al* 2001, WWT Wetlands Advisory Service 2003, Banks *et al* submitted). Carmarthen Bay is unlike other important UK sites for Common Scoter, as a fortunate combination of topography and bathymetry means that many birds are found relatively close to shore, and several vantage points enable much of their distribution to be viewed from land. Consequently, land-based counts frequently provide the highest winter count for the site. These counts have been included in table 2 to provide a definitive assessment for the period, and confirm the site's international importance.

The logistical difficulties and, not least, the expense of undertaking co-ordinated aerial surveys of such large areas means that there are often no more than two or three counts during any given winter in which complete coverage of the sites was achieved (figure 7). Nevertheless, although the winter maxima at all three major sites varied somewhat between each of the five years and, in some cases, within winters, there is no obvious suggestion of a trend of changing numbers at any of the major resorts. These data do suggest, however, that numbers in 2001/02 were relatively low at all sites compared with subsequent winters.

Assessing annual variation is similarly limited by the number of complete counts within individual winters. Nevertheless, during each of the five years, a similar pattern was observed for Liverpool and Carmarthen Bays, with numbers increasing from November onwards and reaching a peak in mid to late winter. On two occasions in Liverpool Bay, the estimate for February has been considerably higher than in other months, perhaps suggesting an influx at that time. (Although that in February 2006 was the only complete survey of the bay that winter, most areas other than Shell Flat were counted in other months, and the increase in February was much greater than might be expected by simply adding the numbers normally found over Shell Flat.) Numbers often remain relatively high in early or even mid spring, with the April count in 2002

exceeding the international threshold. Counts from Carmarthen Bay show a similar pattern, though perhaps with the suggestion of a slightly earlier peak.

Summer surveys have shown numbers begin to build from June, and significant numbers are already present in Liverpool Bay by August. Over 4,000 birds were estimated in this month in 2002, 2003 and 2005. Only one summer survey was made of Cardigan and Carmarthen Bays during the five-year period, though both demonstrated the presence of small numbers. Two old land-based counts, both of over 10,000 birds in July during the 1970s, show Carmarthen Bay has, at least formerly, been of considerable importance at this time of year.

DISTRIBUTION OF COMMON SCOTERS

The ability to record the precise locations of birds during aerial survey has revealed the fine-scale distribution of Common Scoters in Welsh waters (figures 8-13). Two aspects are immediately obvious, namely that the birds make consistent use of key locations throughout the winter, and that they are regularly present at considerable distances from the coast, up to 20 km from shore both over Shell Flat and in Cardigan Bay. Though not shown by the maps presented here, this pattern is consistent between winters also, with birds seemingly faithful to relatively discrete areas in successive years. This picture was largely unknown until the advent of recent aerial surveys and, although several species of seaducks were known to occur well out to sea, particularly off Denmark and in the Baltic (Durinck *et al* 1994, Skov *et al* 1995), birds in British waters were believed to occur relatively close to shore.

The important locations for Common Scoters in Liverpool Bay are over Shell Flat, stretching west from Blackpool and south to the mouth of the Ribble Estuary; a somewhat discrete concentration off Formby Point; in the southern central part of Colwyn Bay, between Towyn and Llanddulas, but with a satellite aggregation to the east, several kilometres offshore between Rhyl and Gronant; just south of the mouth of Conwy Bay; and a regular occurrence, albeit of small numbers, in Red Wharf Bay. Small flocks may, however, be encountered throughout most of the nearshore waters in the bay, particularly off the Wirral. In Cardigan Bay, dense aggregations are consistently found in the coastal strip in the western part of Tremadog Bay; a broad distribution over Sarn Badrig stretches some 25 km southwest from Llanbedr, generally involving relatively low numbers, though high densities are occasionally encountered within this area; and a low density distribution over Sarn Cynfelyn, running southwest from the shore at Borth. The favoured area in Carmarthen Bay, with particularly high densities, is from Amroth to Pendine in the northwest; large numbers are also found immediately off Pembrey; and high counts may also occur in the intervening area, several kilometres out from the mouth of the Three Rivers Estuary.

This distribution shows birds favour large sandy bays, but the striking and consistent feature is their occurrence in shallow waters, in nearly all cases less than 10 m deep. The majority of Common Scoters are thus found within 6 - 8 km offshore, but aerial surveys have shown that, as elsewhere in Europe, scoters occur wherever there are suitable conditions, and they are regularly found 20 km or more from the coast where there are shallow waters. The exception to this general pattern is that they appear to avoid the mouths of large rivers and estuaries. This is particularly evident for the Dee and Mersey Estuaries and the mouth of Morecambe Bay. It is likely that disturbance is a factor at these locations. Common Scoters flush easily in the presence of boats, as they do for planes, and this reaction can pass quickly through a flock. Just one small vessel may put very large numbers to flight, even if the far edge of the flock is a considerable distance from the boat (pers obs). But birds are largely absent also from the mouths of rivers with little boat traffic, such as the Ribble, and, in Carmarthen Bay, the Three Rivers Estuary and Burry Inlet. In these locations, brackish water and tidal currents result in an infauna - which

Figure 8. Distribution of Common Scoters recorded during aerial survey in Period 1 (late summer), 2001/02 to 2005/06.

Relative density is the number of scoters counted per kilometre of survey effort, by 2×2 km grid cell (see text).

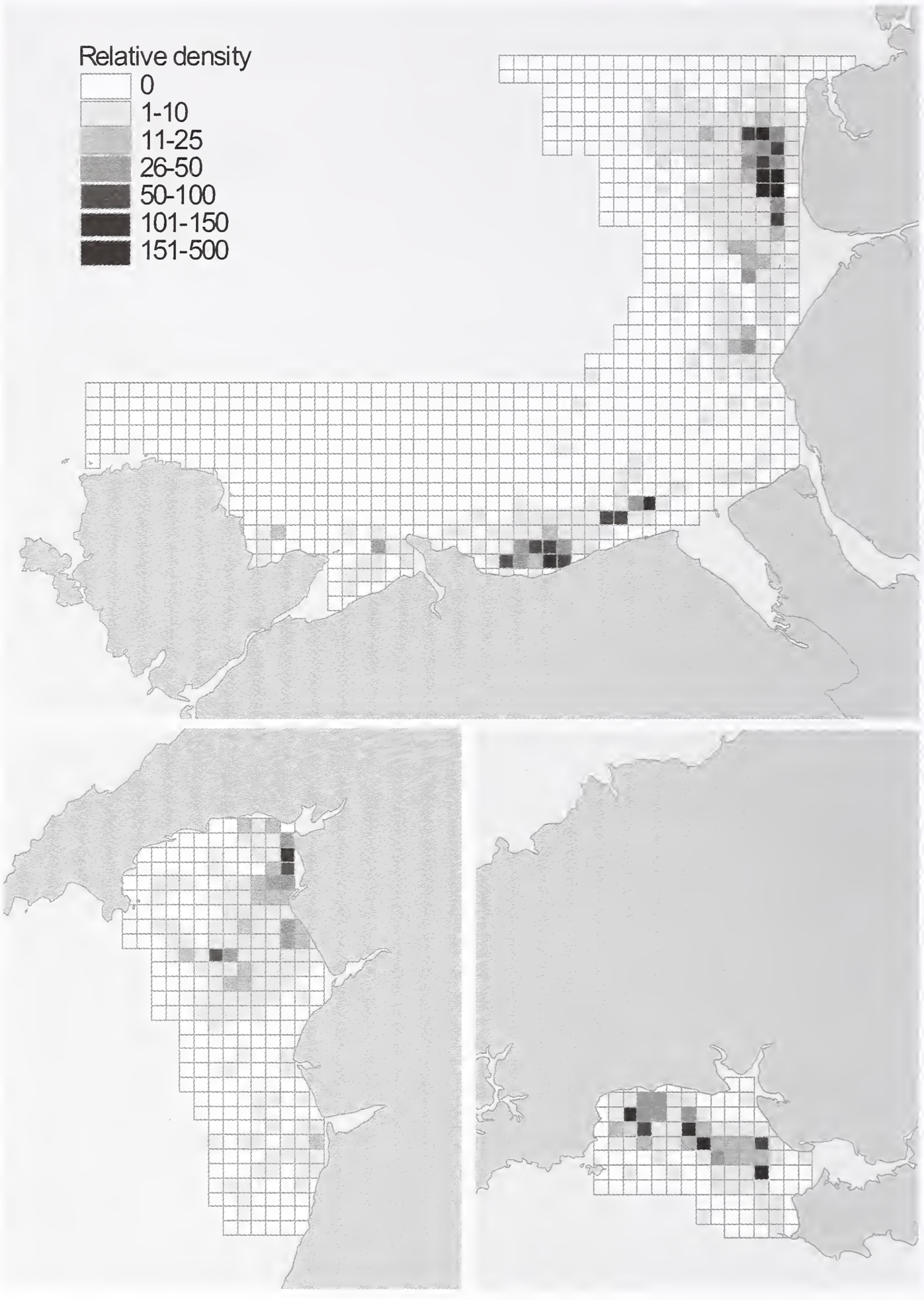

Figure 9. Distribution of Common Scoters recorded during aerial survey in Period 2 (autumn), 2001/02 to 2005/06.

The relative density for one 2×2 km grid cell in the centre of Carmarthen Bay is shown here as being in the highest density category, but the actual value was 653.

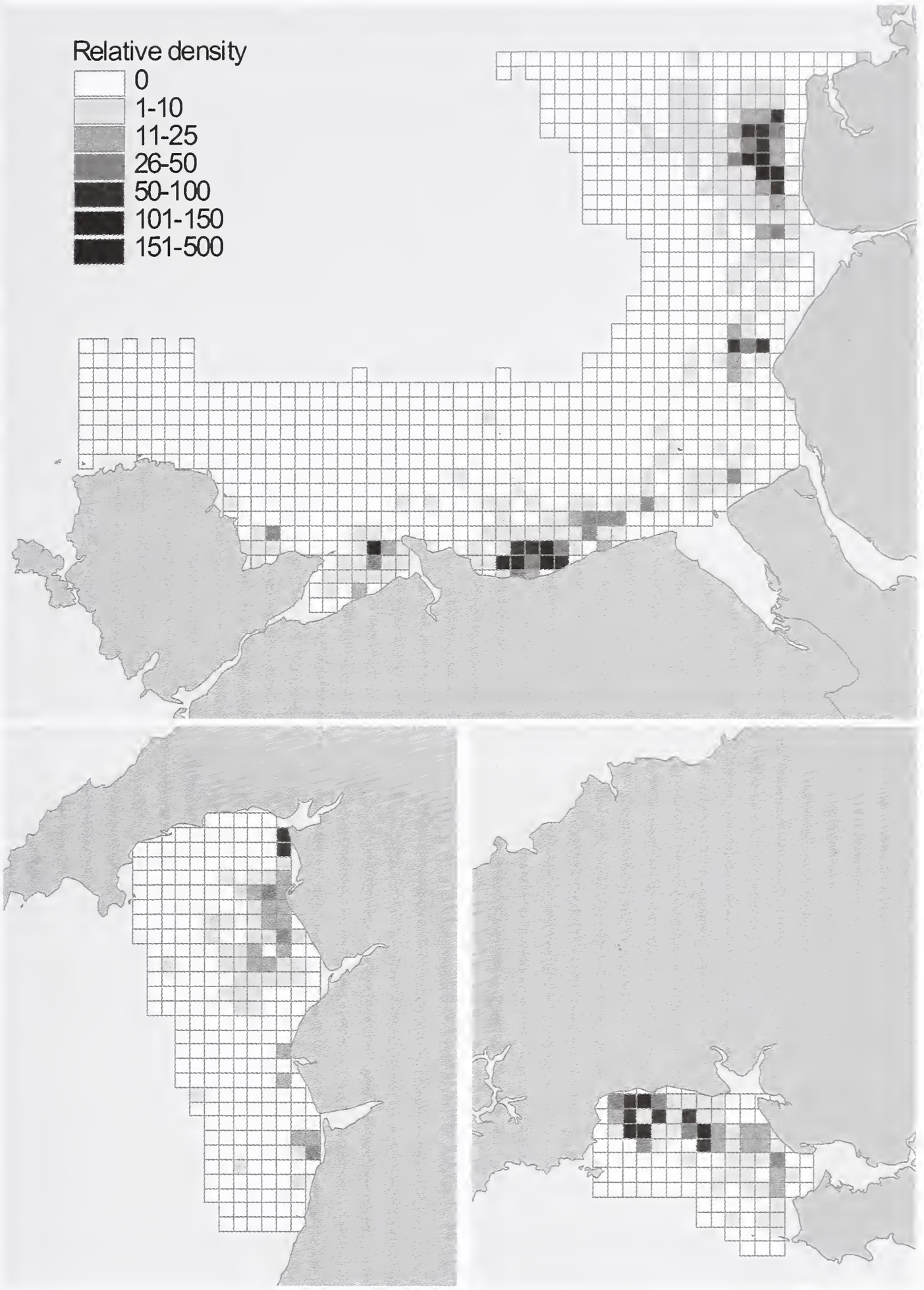

Figure 10. Distribution of Common Scoters recorded during aerial survey in Period 3 (early winter), 2001/02 to 2005/06.

includes the prey of scoters - that is quite different to open coast areas (*eg* Moore & Little 1994, Woolmer 2003), and strong currents in these areas may also affect the foraging ability of scoters.

Scoter distribution changes subtly within the key locations during the course of a winter. This is particularly pronounced at Shell Flat. Here, large numbers present in autumn and early winter are gathered largely just offshore, in an aggregation running roughly parallel to the coast at Blackpool as far south as the Ribble (figures 9 & 10). As winter progresses, birds are found further west so that, by mid and late winter, the distribution more closely matches the 10 m depth contour of Shell Flat, with some dense concentrations more than 15 km from shore; relatively few birds are then found in the shallow waters near the mouth of the Ribble (figures 11 & 12). A similar change is observed in Colwyn Bay, the other key location within Liverpool Bay, though the shift in distribution is less dramatic as the area of available shallow water is much smaller.

Such changes are likely to reflect foraging efficiency and the depletion of prey. At the start of the winter, birds exploit shallower waters, where they expend less energy making shorter dives. But as prey in these areas become scarce as the winter progresses, birds are forced into deeper water to find food. Such a pattern is less obvious, but nevertheless appears to be present, for the large sarns in Cardigan Bay, although there is a dense aggregation offshore in autumn. It may be that further surveys here are required to establish if there is a consistent pattern.

Interestingly, there appears to be no obvious movement offshore in Carmarthen Bay as the winter progresses. Distribution from early to late winter appears to be remarkably consistent and, indeed, birds are found close to shore throughout this period. Densities are generally lower off Pembrey, despite extensive shallow waters here, presumably a consequence of the two river mouths either side of this area. Distribution in the central part of the bay might also be affected by disturbance from military activity (shells are fired from land into the sea southeast of Pendine), although scoters appear to show little direct reaction to shells landing nearby (LE Smith pers obs).

Spring sees a marked change in distribution in Liverpool Bay, the only site for which surveys were made at this time of year. Although the key locations of Shell Flat and Colwyn Bay are still important, with birds occurring well offshore, numbers are considerably smaller than in winter. By contrast, densities off Formby Point and in Conwy Bay increase so that their peak numbers occur at this time. Although these areas are of marked importance during winter, this increase means that their relative importance within Liverpool Bay is dramatically increased in spring. It is difficult to equate such an apparently marked shift in distribution with continued movement in response to food depletion, and it is speculated that this pattern may represent a change in ecological requirement at this time - or perhaps in behaviour prior to migration - although the reasons for this are unknown.

Common Scoters were encountered during most late summer surveys in Liverpool, Cardigan and Carmarthen Bays (figure 8). Although present in only small numbers, there is a marked and consistently different pattern of distribution at this time. Very few birds are found within 3 - 4 km of land. Such distributions off Germany and Denmark during late summer involve moulting birds (Bräger *et al* 1995). Like other ducks, scoters are flightless for a period of 4 - 6 weeks during moult, and thus seek waters further from potential danger than at other times. In Denmark, birds were shown to be distant from land and from areas used regularly by fishing boats during the moult period. Aerial surveys during late summer in Liverpool Bay recorded several flocks in flight, and no flocks diving were seen in front of the plane, as has been observed for birds in active moult in Denmark (IK Petersen pers comm). But several discrete and uniformly dense aggregations were encountered, an atypical distribution for Common Scoters

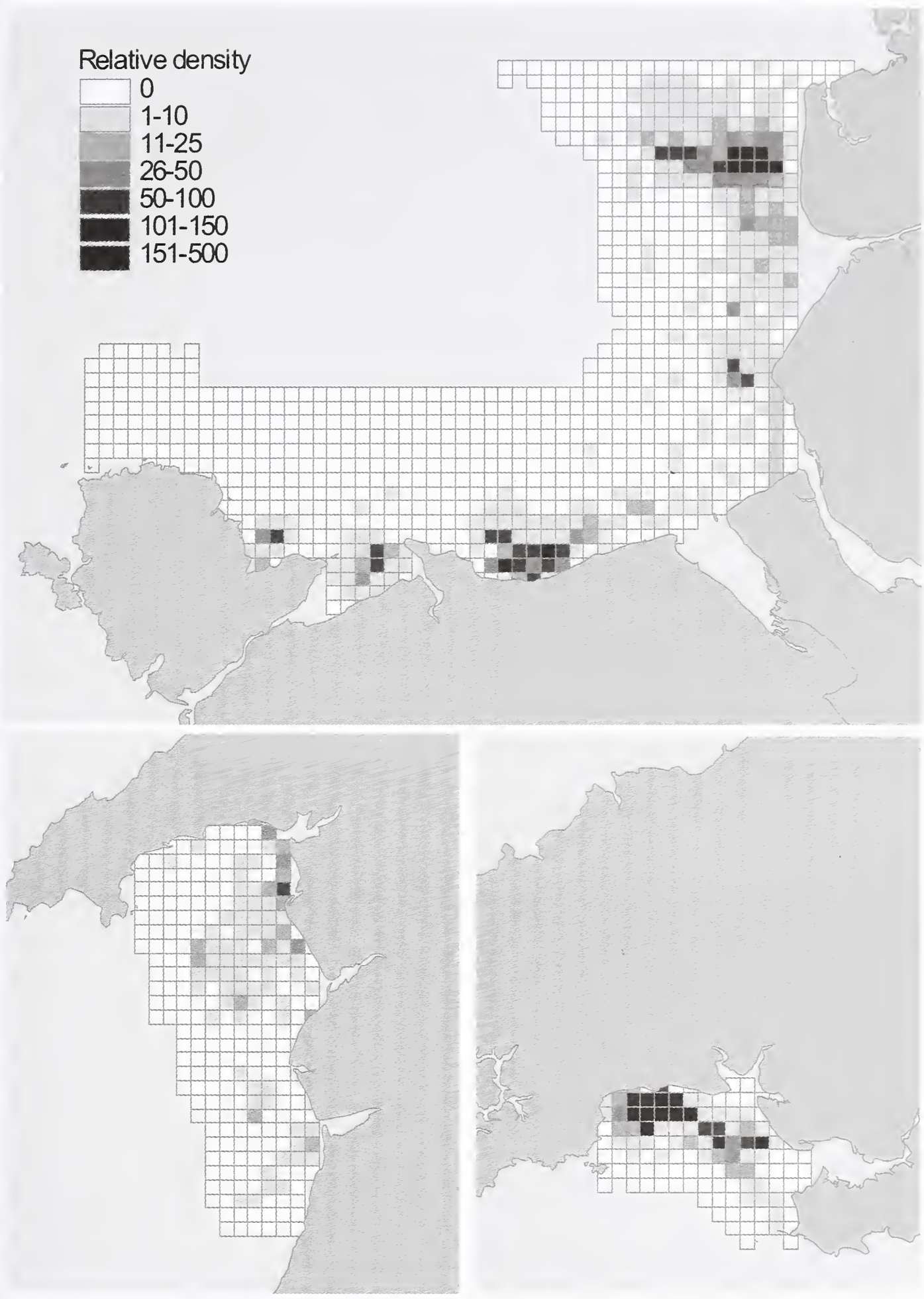

Figure 11. Distribution of Common Scoters recorded during aerial survey in Period 4 (mid winter), 2001/02 to 2005/06.

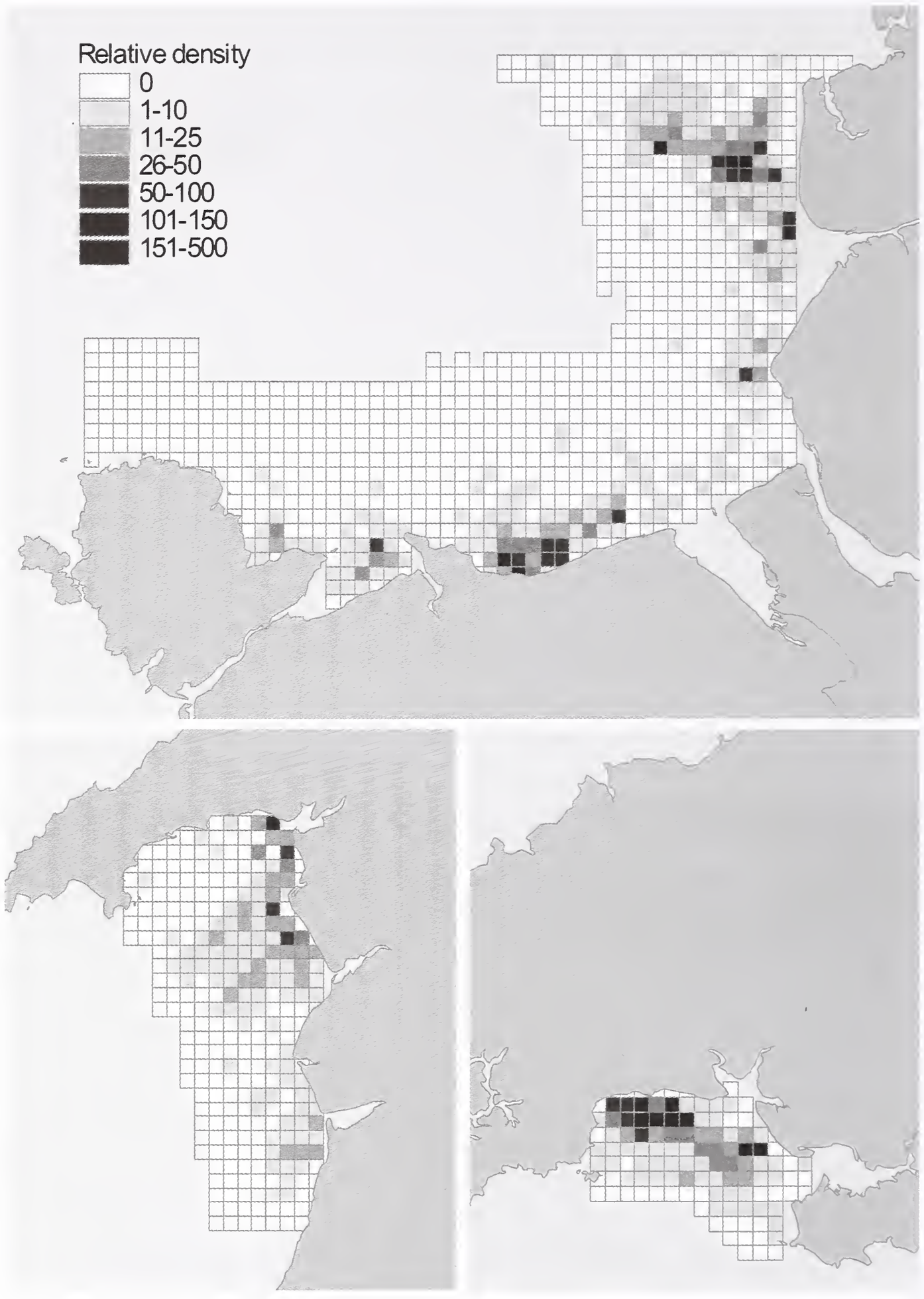

Figure 12. Distribution of Common Scoters recorded during aerial survey in Period 5 (late winter), 2001/02 to 2005/06.

Figure 13. Distribution of Common Scoters recorded during aerial survey in Period 6 (spring), 2001/02 to 2005/06.

No flights were made of Cardigan or Carmarthen Bays during this survey period.

which, at least in winter, are generally found in loosely aggregated and unevenly distributed small to medium sized groups. Such distribution, both at a coarse and a fine scale, at several locations in all three sites around Wales provides strong circumstantial evidence that they are used by moulting Common Scoters.

DISCUSSION

Aerial surveys undertaken for the All Wales Common Scoter Survey have greatly advanced our knowledge of the numbers and distribution of this species' non-breeding status in British waters. Numbers present in winter are considerably larger than previously suspected, and those in Liverpool Bay alone greatly exceed the previous estimate for the whole of Britain.

In particular, Shell Flat, a shallow sandbank extending west from Blackpool, was discovered to be the most important UK site for Common Scoters, regularly holding in excess of 20,000 and on occasion up to 50,000. Such a finding is all the more remarkable given that scoters were not known to occur at this site before the advent of the AWCSS. Previous counts along the English coastline of Liverpool Bay rarely exceeded 1000 (summarised in Oliver *et al* 2001, mainly from local bird reports) and most observations were of birds in flight in early morning, presumed to be relocating to feeding grounds having been drifted by currents overnight. A count of 3200 off Blackpool in the late 1990s was considered 'unprecedented'.

The confidence intervals associated with the estimates of Common Scoters are particularly large, a consequence of their markedly clumped distribution (few or no birds are encountered over much of the surveyed area, and the majority is encountered in dense aggregations restricted to relatively small areas). Work is ongoing to develop new analytical techniques that improve the precision of the estimates.

Although aerial surveys enable rapid coverage of large areas (roughly 1200 km^2 in a single flight), a complete count of Liverpool Bay necessitates survey over several days, allowing the possibility for birds to move between the major sites and therefore to be missed or double-counted. The extent to which this occurs is unknown, but no substantial movements of scoters over large distances have been observed during aerial surveys (albeit that movements at night, in the early morning or in the evening would not be detected as flights are made during the middle of the day). Further, whilst birds in flight are regularly seen during casual observations from vantage points on the English coast, most such records are during migration periods and usually involve relatively small numbers (*eg* Oliver *et al* 2001). Consequently, movements of large numbers of birds between the major aggregations are not thought to occur on a regular basis, and the estimates of total numbers in Liverpool Bay are believed to be representative.

The assessment of the importance of Cardigan Bay for Common Scoters is best regarded as provisional. Relatively few surveys were made of this site, and only two during December or January, months that might be expected, on the basis of numbers elsewhere, to be the time of peak occurrence. Further surveys are needed, particularly in mid and late winter, both to be confident of peak numbers at this site and to contribute to an estimate of total numbers in Wales.

Surveys show large numbers were consistently present at the key resorts during the winters 2001/02 to 2005/06. Summing average numbers from this period suggests a total of 40,000 - 50,000 Common Scoters are regularly present in Welsh waters. A further 20,000 - 25,000 are found off the English coastline of Liverpool Bay. During marked peaks, which have occurred during February in two winters and which suggest an influx of birds at this time, an additional 20,000 - 30,000 birds may be present in Liverpool Bay as a whole. Such numbers greatly exceed previous estimates.

Aerial surveys have been undertaken elsewhere in the UK, particularly since 2003/04, and have covered important sites for Common Scoters - notably in the east Scottish Firths and off Norfolk and Lincolnshire. Numbers there have, however, been broadly similar to those found previously by land-based counts. Nevertheless, it appears that the true British total is likely to number more than 100,000 birds, considerably in excess of the currently accepted national estimate of 50,000 (Kershaw & Cranswick 2003). This increase is thought to reflect improved estimates for the key resorts around Wales, rather than any genuine change in status, as large numbers were recorded in all five winters. This further supports the assertion that comprehensive survey under the AWCSS has enabled the first accurate assessment of Common Scoter numbers in Welsh waters.

These aerial surveys have also shown for the first time that Common Scoters may occur at considerable distances offshore in British waters. Although such distribution is known for seaducks elsewhere in northern Europe, perceived wisdom was that birds off our coasts were found relatively close to shore, to the extent that, under ideal conditions, they could probably be counted with reasonable accuracy from shore. Throughout the key resorts off Wales - in Colwyn, Conwy, Cardigan and Carmarthen Bays - and off northwest England, large numbers of birds are consistently found in excess of 5 km from shore, while over Shell Flat and the sarns in Cardigan Bay, distribution regularly extends 20 km from land. At several sites, and at certain times of year, it appears that even those birds nearest to shore are still too far from land to be detected by shore-based counts. Aerial surveys are, therefore, essential to determine the numbers and accurate distribution of Common Scoters in the eastern half of the Irish Sea.

In addition to the marked improvement in knowledge and data, the AWCSS has delivered several significant conservation successes. Carmarthen Bay has been classified as the UK's first marine SPA, on the basis of its importance for Common Scoters. The combination of land and aerial surveys (Woolmer *et al* 2001) confirmed the regular presence of internationally important numbers, and the precise locations of birds recorded by aerial survey enabled principles for the placement of SPA boundaries to be developed (Webb *et al* 2004). The importance of Liverpool Bay as a possible SPA is currently being assessed using aerial survey data (Webb *et al* 2006b). AWCSS data have also shown that numbers of Common Scoters in Carmarthen Bay have returned to levels found prior to the *Sea Empress* oil spill, suggesting the recovery of at least that part of the ecosystem in the bay linked to the ducks (Banks *et al* submitted). Indeed, the estimate of 28,500 in 2005/06 is the highest ever made for the site. Survey work is continuing, both to monitor the site and to determine standardised monitoring protocols for the SPA (Banks *et al* 2004).

AWCSS data have also informed the consenting process for construction of offshore windfarms in Liverpool Bay. Two have already been built, and others are under construction, where aerial survey data have indicated that the development will not have an unacceptable impact on the bird interest. The largest proposed development in the bay was for three windfarms along the length of Shell Flat, made at a time when the number of Common Scoters there was unknown. The AWCSS discovered the considerable importance of this site, and the data have helped safeguard the premier UK site for Common Scoters from a potentially catastrophic development, given the considerable sensitivity of this species to disturbance. The data have also enabled the potential development to be re-sited, and a proposal has been submitted to build just to the north of Shell Flat, in an area now known to support very few birds.

The AWCSS has also been responsible for the resurgence of aerial surveys in the UK. It pioneered the application of new methods and, in bringing together and successfully serving the various needs of Government, industry and NGOs, provided the seed for the current extensive programme of aerial surveys in the UK.

Although the AWCSS has established the importance of Welsh waters and Liverpool Bay for Common Scoters, several challenges still remain. The resources for continued surveys must be secured, so that the numbers of birds and the importance of these sites are monitored. Improved analytical techniques are also required to provide greater precision in the estimates themselves, and enhance our ability to predict and detect changes in numbers and distribution, particularly in response to the many human activities in marine waters. The precise information on the location of birds provided by aerial survey will remain invaluable for such needs. Wider issues also remain, notably to determine the breeding grounds of birds wintering in Wales and Liverpool Bay, to assess the degree of turnover and interchange within the bays and with other UK sites, and to assess the cumulative effect of the many offshore developments and activities proposed both within the survey area and elsewhere. Such issues are likely to prove major challenges, both technologically and financially.

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BREEDING RAVENS *Corvus corax* ON THE GOWER PENINSULA

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SUMMARY

We assessed the Raven population of the Gower over a 75 year period from 1930 to 2004 using historical data from two egg collectors who pursued Ravens on the peninsula for 25 years in the first half of the 20th Century, also from the archives of the Gower Ornithological Society and by field surveys in 2002-04. Our study indicates that the annual breeding population has been relatively stable with a typical annual average of about a dozen breeding pairs, though there was evidence of a temporary decline in the late 1950s and 1960s. The increase in breeding Raven densities seen elsewhere across Wales in the last 25 years has not been exhibited on the Gower peninsula, indicating population limitation. Over the 75 years there has been a distribution shift away from coastal sites to inland nesting sites, probably in response to recreational disturbance on the coast. Clutches are on average larger than those recorded elsewhere in the UK with a mean of 5.3 eggs per clutch. Ravens in Gower typically commenced egg-laying in the first week of March during the period 1935-59, but in 2002-04 the mean first egg date was 21st February and may possibly be a response to climate warming.

INTRODUCTION

Ravens *(Corvus corax)* were once heavily persecuted and restricted to the remote uplands and coastal cliffs of Wales but during the 20th Century there was some recovery in the population, aided by a reduction in deliberate persecution during the two World Wars (Lovegrove et al., 1994). The Atlas of Breeding Birds in West Glamorgan (Thomas, 1992) reported that Ravens are a common sight on the cliffs of south Gower, whilst the Birds of Glamorgan (Hurford & Lansdown, 1995) noted that some population changes had taken place over the course of the 20th Century. Ravens occupy traditional nesting ranges that can be used by a succession of birds over many decades and there may be several, sometimes widely dispersed, nesting sites within each range.

The inter-war years were the 'heyday' of egg collecting in Britain and at this time the pursuit was almost synonymous with the study of ornithology. Ravens were a favourite target for the collectors because they nested early in the year, before most other species begin to breed, whilst the taking of the eggs from their nests, often in difficult to reach spots in remote places, presented something of a 'sporting challenge'. Several egg collectors were active in the Gower area but two in particular scoured the area for nests virtually every year for twenty five years from the mid 1930s, these being Lindsey Eccles and Dr. Stennett Sloane Chesser. Eccles was the son of a steelworks owner at Baglan, who later turned to farming on the Gower when the steel industry was nationalised, whilst Chesser was a GP in Surrey whose first wife was from Kilvrough Manor (Cole & Trobe, 2000). From 1935-59 these men, and a few other collectors, took at least 65 clutches of eggs from Raven nests on the Gower.

The data that accompanies the egg collections of these two 'oologists', together with their diaries are now a valuable source of historical information on the status of the Raven in Gower. For this study we have collated this information and that relating to breeding Ravens from the archives of the Gower Ornithological Society in order to examine any population trends over the last 75 years. Over the period 2002-04 we made an effort to visit the known breeding ranges to assess the current status of the breeding population.

METHODS

The Gower peninsula of the West Glamorgan coastline is approximately 25 km long and has a land surface area of ca. 160 km2 lying west of a line from the Clyne Valley to Gowerton. In addition there is an extensive tidal zone, particularly in the saltmarshes of the Loughor estuary in the north. The landscape is largely mixed agricultural land with extensive commons and a small coverage of woodland (ca. 7% of the peninsula, confined mainly to the deep valleys and a few plantations).

The egg collections of Lindsey Eccles and Dr. Stennett Sloane Chesser are now held in public museums, the former in the Swansea Museum and the latter at Oxford Museum. Data cards or labels giving the name of the site and the date on which the eggs were taken accompany the eggs. Original, but incomplete, diaries kept by Eccles are also held along with the egg collection in Swansea Museum, whilst the complete diaries of Dr. Chesser were made available to us. We used these information sources to determine which breeding sites were occupied and, from the diaries alone, those which were not occupied, during the period 1930 to 1959 (excluding the years 1943-47). In addition, we were also able to obtain data on clutch sizes and laying dates.

For the period 1968 onwards we were provided with the Raven breeding data held by the Gower Ornithological Society. We had very little data available to us for the period 1960-67. For each decade over the period 1930-99 we have estimated the annual breeding population from the data available to us.

From 2002 to 2004 we visited the Gower on several occasions during the breeding season to check the former nesting haunts for breeding evidence. We visited all the known coastal ranges except those on Worm's Head and Burry Holms. Inland we visited seven of 12 previously recorded nesting sites.

RESULTS

Breeding Population

Our population estimates for the 75 year period covered in our study are given in Table 1.

Table 1. Breeding populations of Ravens in the Gower peninsula. Min. and Max. represent the lowest and highest possible number of breeding pairs in any one year, whilst the Est. Ave. is our estimate of the typical annual breeding population over the decade.

Time Period	Est. Annual Average	Min-Max
1930-39	12	12-14
1940-49	14	11-16
1950-59	12	7-16
1960-69	9	6-14
1970-79	12	9-17
1980-89	12	12-18
1990-99	11	9-13
2002-04	11	8-15

During the 1930s Chesser and Eccles visited 42 Raven nest sites within 14 different breeding ranges on Gower, comprising 13 coastal ranges and one newly established tree nest inland at Moorlakes in 1939 (Figure 1). In 1935, together with another noted egg collector, John Walpole-Bond, they visited 12 of 13 coastal territories and found all of them occupied by breeding pairs and it seems reasonable to assume that during the mid to late 1930s the annual breeding population was around a dozen pairs.

Figure 1. Distribution of Raven breeding ranges on the Gower peninsula during the 1930s

During the 1940s (except in the years 1943-46), Chesser and Eccles visited 34 nest sites in 16 different ranges, with the two new ranges being tree nests inland. They never visited all the possible breeding ranges in any one year but in 1949 they checked 11 sites and found them all occupied. There appears to have been a small population increase over this decade.

By the early 1950s Ravens also started breeding at a new coastal haunt in Bishopston parish, extending the breeding distribution eastwards along the south coast. Over the period 1950-54, 93% of the 43 nesting territories visited by Eccles and Chesser were occupied by breeding pairs. This contrasts with only 43% occupied at the 42 sites visited during 1956-59, suggesting that the breeding population was in decline during the latter half of the decade when, in 1959 only 5 of 11 territories visited were occupied.

Breeding records are rather sparse from the 1960s and we have only six breeding records for the decade at six different ranges. In the mid 1960s the Gower breeding population was reported to be 14 pairs (Hurford & Lansdown, 1995), though Heathcote *et al.* (1967) reported that there were only three or four regularly occupied sites on the Gower cliffs, with at least one tree-nesting site on the peninsula and another a little farther inland.

Thanks to the archive of the Gower Ornithological Society, the number of records available increased again during the 1970's, with 17 different ranges reported; eight coastal and nine inland. The growth of the conifer plantation on Whiteford Burrows created a new tree nesting site in an area where no suitable nesting place existed before. Ten nest sites were reported in 1971 and in 1978 breeding was confirmed at 12 territories, seven on the coast and five at inland sites.

During the Glamorgan Atlas survey period, 1984-89 inclusive, breeding was confirmed in 12 tetrads, regarded as probable in a further six and possible in seven more. However, during the six-year survey period there was some switching between alternative nesting sites within single breeding ranges, which resulted in breeding in more than one tetrad. Archive records exist for 15 different ranges, four of which were tree nests inland. In the late 1980s the annual breeding population was probably in the region of a dozen pairs.

In the 1990s a maximum of four breeding attempts were recorded in any one year to the county recorder and nine different breeding ranges, all coastal sites, were reported over the decade. Inland breeding sites were probably under-reported rather than absent during this decade and it's likely that at least four ranges were occupied (based on occupancy prior to and following the 1990s).

During 2002-04 we checked 13 of 15 known coastal ranges, only six of which were occupied (i.e., 46%). This level of occupancy suggests that one of the two unchecked ranges may have been occupied and we estimate the coastal population to have been 7 breeding pairs (range 6-8 bp). We also checked seven of 12 known inland ranges, only two of which were occupied (i.e., 29%). From this we estimate that two of the five unchecked ranges were likely to have been occupied and estimate that the inland population was 4 breeding pairs (range 2-7 bp). Overall, we estimate that the annual Raven breeding population on the Gower peninsula during 2002-04 was 11 breeding pairs (range 8-15 bp; Figure 2).

Clutch Sizes and Laying Dates

Over the 25 year period 1930-54, egg collectors, principally Eccles and Chesser, took at least 59 clutches of Raven eggs from the Gower peninsula, which accounted for about 25-30% of the clutches laid each year. The mean clutch size was 5.3 eggs ($N = 50$ clutches; Table 2), whilst the mean first-egg date of 32 clutches was the 4th March (range 12th February to 11th March). Eccles

Figure 2. Distribution of Raven breeding ranges on the Gower peninsula in 2002-04. *Filled circles represent occupied ranges and open circles represent ranges not checked during our survey*

and Chesser ended their egging trips on the Gower coast in 1959, so we have no data on clutch sizes and laying dates from 1960 onwards. For the years 1956-59, when the population apparently declined, the mean clutch size was 5.3 eggs ($N = 6$ clutches; Table 2), whilst the mean first-egg date of six clutches was the 2nd March (range 18th February to 6th March). In 2002-04 clutch size was recorded at six nests, with a mean clutch size of 5.5 eggs (Table 2) and the mean first-egg date of five clutches was the 21st February (range 8th February to 14th March).

Table 2. Raven clutch sizes during three periods from 1930-2004. Data for the periods 1930-54 and 1955-59 was drawn from the diaries of Eccles and Chesser, whilst data for the period 2002-04 was obtained during our own field surveys.

Time Period	Clutch Size					Mean
	C3	C4	C5	C6	C7	
1930-54	6	4	15	19	6	5.3
1955-59	0	1	2	3	0	5.3
2002-04	1	0	1	3	1	5.5
Overall	7 (11%)	5 (8%)	18 (29%)	25 (40%)	7 (11%)	5.3

Nesting Sites

We classified the 12 coastal breeding ranges that we visited in 2004 in terms of their level of recreational disturbance. Sites were classified as 'high' or 'low level of disturbance', with sites categorised as 'high' being close to and above a coastal path, on a cliff frequented regularly by climbers or close to a major tourist hotspot. All 12 ranges were regularly occupied in the period 1930-54 but only six were occupied in 2004, five of which were classified as low disturbance sites (Table 3). Of the seven ranges categorised as being subject to a high level of recreational disturbance only one was occupied in 2004.

Tree nesting was first recorded on the Gower in Oxwich Bay prior to 1935 and the first inland nest was reported in 1939 at Moorlakes and subsequently pairs bred in trees in at least ten other inland ranges and one coastal range, whilst pairs utilised rocks in two of the inland quarries (one of which had an alternative tree nesting site). Most of the tree nests appear to have been built in Scots Pines (*Pinus sylvestris*).

Table 3. The status and rank, in terms of the level of recreational disturbance, at 12 coastal ranges checked in 2004

Range	Rank	Status
Bishopstone	Low	Occupied
Pwll Du	High	Unoccupied
Southgate	Low	Occupied
Threecliffs Bay	High	Unoccupied
Oxwich	High	Unoccupied
Holys Wash	High	Unoccupied
Culver Hole	High	Occupied
Overton	High	Unoccupied
Pitton	High	Unoccupied
Mewslade	Low	Occupied
Bluepool Bay	Low	Occupied
Llanmadoc Tor	Low	Occupied

DISCUSSION

Over the 75 years covered by our study we believe that the breeding population has fluctuated around a typical annual quota of a dozen pairs. The adoption of inland tree-nesting sites from the late 1930s heralded a small increase in the annual breeding population. Increases were also reported throughout other parts of Glamorgan and elsewhere in Wales over the same period (Hurford & Lansdown, 1995; Lovegrove *et al.*, 1994). Our data suggests that at its peak, the breeding population on the whole Gower peninsula amounted to approximately 14 pairs and the claim that 12 pairs bred in the Pennard area alone in the early 1950s is undoubtedly incorrect (James, 1961 *cited in* Hurford & Lansdown, 1995). This reported breeding density (which would equate to *ca.* 120 bp/100 km^2) is unprecedented and simply not credible, besides it seems impossible that such an aggregation of breeding Ravens would have escaped the attention of Eccles and Chesser, who scoured this area annually; they recorded three breeding pairs along the 5 km of coastline in the Pennard area during the early 1950s.

During the 1960s the annual population was probably between 6-14 breeding pairs and the low occupancy levels of the late 1950s suggest that there may have been a decline in the 1960s and that the annual population was probably closer to six pairs than 14 pairs. A decline in the breeding population reported from the mid-1950s was also apparent along the Vale coast of Glamorgan and was attributed to increased levels of recreational disturbance (Hurford & Lansdown, 1995). By the end of the 1970s there were 12 breeding pairs recorded, similar to the population of the 1930s, but there was a marked difference in nest site distribution between the two periods because in 1978 five of the 12 recorded ranges were inland. Though the breeding numbers were similar there was a marked difference in the distribution of nesting ranges with fewer pairs nesting along the coast and more inland.

In the latter half of the 20th Century the Gower developed considerably as a holiday destination and since the 1950s caravan sites have become established near several beaches. The coastal paths are now well traversed at all times of the year, whilst some of the favoured limestone nesting-cliffs on the south coast are regularly assailed by rock-climbers. Ravens appear to be more tolerant of recreational disturbance if footpaths pass above rather than below a nesting

site. Many of the limestone cliffs used as nesting sites in the past have nowadays been abandoned for the secluded 'head coves' closer to the sea and out of sight below the coastal paths and several nesting sites that once supported separate pairs are now encompassed as alternative sites within a single range. Tolerance of high levels of disturbance will vary among individual birds and the occupation of breeding ranges close to tourist 'hotspots' is expected to be sporadic depending on the tolerance level of the individual territory holders. Nesting at former regular haunts in Threecliffs Bay and Oxwich Point has now become very infrequent and the changed status of these breeding ranges could be the result of recreational disturbance. Nevertheless, the traditional nesting site in the medieval pigeon house of Culver Hole is still regularly occupied despite the huge number of visitors to the site.

Recreational disturbance may have influenced the distribution of breeding pairs but it appears not to have affected their overall number on the peninsula. In contrast to the population trends elsewhere in Glamorgan and Wales, where significant increases in the Raven breeding population have been witnessed, the population appears to have remained fairly stable since the 1970s. Our study indicates that the claim by Mullard (2006) that Ravens "now breed at very high densities on the cliffs" of Gower is incorrect. There were only four breeding pairs along the extensive coastal cliffs of the south Gower coast, a further two pairs on the northern coast and at least one inland in 2004. Nevertheless, our estimated breeding population of 11 pairs in 2002-04 equates to a breeding density of 5.6 bp/100km^2, which compares well with that found in 2005 on the Lleyn Peninsula of North Wales (4.9-5.7 bp/100 km^2; Driver, 2006). The population size is probably limited primarily by food supply and, judging by the stability in the number of breeding pairs, this has been relatively constant for at least the last 30 years. It would be interesting to know more about the diet and foraging behaviour of the Gower Ravens in relation to food supply. For example, how much do the birds forage in the littoral zone of the coast compared to inland?

Clutch sizes have remained fairly constant over the 75 years of study and tend to be larger than those recorded elsewhere in Britain i.e., 5.3 eggs per clutch *cf.* 4.8 eggs per clutch in Britain as whole (data in Ratcliffe, 1997). Over the half the clutches produced on the Gower have six or seven eggs, suggesting that food supply is plentiful for the pairs that breed here. Large clutches sizes have also been reported for coastal populations in North Wales, with a mean of 5.6 and 5.3 eggs on Anglesey and the Lleyn Peninsula respectively (J. Driver, *pers. com.*). Overall, the mean laying date (first egg) for 43 clutches was the 3rd March. The sample size is very small, but the mean first egg date was much earlier in 2002-04 than in the previous time periods and the spread of laying dates was also the greatest (i.e., mean laying date of 21st February with a laying spread from 8th February to 14th March). Given that a large sample of data exists for laying dates over the period 1930-59 it would be interesting to obtain modern data to see if Raven laying dates have advanced in line with the recent trend of climate warming.

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WALES RING OUZEL *Turdus torquatus* SURVEY IN 2006

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INTRODUCTION

Ring Ouzels are known to have been in decline across Wales since at least the 1970s (Gibbons *et al* 1993; Tyler and Green 1994, Lovegrove *et al* 1994). A national survey in 1999 aimed to set a baseline for future monitoring of breeding Ring Ouzels across the UK, and a decline of 39-43% was recorded in tetrads known to have been occupied during the 1988-91 Breeding Atlas (Wotton *et al* 2002).

This 2006 survey aimed to re-survey as many as possible of the tetrads in Wales that were visited in the 1999 national survey to detect any population trends since then. A secondary aim was to record habitat features in occupied and unoccupied tetrads, and to see if there is any association between habitat and retention of Ring Ouzel. This paper reports on the results of the tetrad survey and the second aim will be analysed and reported elsewhere.

METHODS

The survey followed the methods of the 1999 survey as described by Wotton *et al* (1999) using a tape playback to locate territorial Ring Ouzels. Tetrads were chosen from those surveyed in 1999 to give as wide a coverage of Wales as possible with the available observers. Complete re-survey of the 1999 tetrads was not achieved due to a shortage of observers or surveys not completed for reasons outside our control. However, those that were covered in 2006 provided a good sample of geographical and habitat range across Wales.

Each tetrad was visited twice, over a single day each time. The first visit was between mid-April and mid-May. The second visit was between mid-May and the end of June. Mornings were

considered preferable, but it was recognised that surveys of some sites might take longer than a morning to complete, and in the 1999 survey use of the tape playback meant that surveys were found to be successful throughout the day. Wet weather and very windy conditions were avoided.

Four transects, roughly 500m apart were walked where possible through each tetrad, starting 250m in from one corner of the tetrad. Transects tried to avoid following linear features, and cut across habitat features. All areas of the tetrad were covered, even if the habitat appeared to be unsuitable, although improved pasture, dense woodland and conifer plantations were generally excluded (though forest edges were included as Ring Ouzels have bred in forestry in Wales (Tyler and Green 1994)).

The tape of Ring Ouzel call and song was played within c250m of each part of the tetrad, so first play was 250m along the first transect, then every 500m. At each point the tape was played for 20-30 seconds. After which, the area was observed for 5-10 minutes to record any Ring Ouzel activity. Any birds seen or heard were marked on a map.

On record sheets provided to each observer, the tetrad, observer name and dates of each visit were recorded along with the number of birds seen on each visit. After the second visit the maximum number of pairs considered to be in the tetrad were recorded. Finally, a brief description of the vegetation of the tetrad (e.g. mainly heather, mainly unimproved grassland, mosaic of heather and grass, mainly forestry and so on) was included.

RESULTS

A total of 26 tetrads, out of the 35 in Wales covered in the 1999 survey, were re-surveyed in 2006. Total maximum numbers of Ring Ouzels within those tetrads fell from 81 to 25 breeding pairs - a 69% decline. Totals for each tetrad, along with the 1999 results for comparison, are given in Table 1.

Declines appeared to be similar across Wales. Denbigh (2 tetrads) experienced a 75% decline; Merionnydd (17 tetrads) a 69% decline; Radnor (1 tetrad) 100% decline; Brecknock (3 tetrads) 78% decline; Glamorgan (1 tetrad) 100% decline. Only Monmouthshire (2 tetrads) experienced an increase from 0 to 1 pair.

Table 1. Ring Ouzel survey of Wales 2006: Results by tetrad

County	10km square	Tetrad	1999 min	1999 max	2006 min	2006 max
Meirionnydd	SH61	SH6812	0	0	0	1
Meirionnydd	SH62	SH6224	3	5	0	1
Meirionnydd	SH62	SH6622	5	8	0	1
Meirionnydd	SH63	SH6230	2	3	0	1
Meirionnydd	SH64	SH6644	5	7	3	3
Meirionnydd	SH71	SH7012	7	10	3	4
Meirionnydd	SH71	SH7212	8	10	0	0
Meirionnydd	SH71	SH7412	4	5	4	4
Meirionnydd	SH71	SH7414	2	3	1	1
Meirionnydd	SH72	SH7824	0	0	0	0
Meirionnydd	SH72	SH7828	2	2	0	0
Meirionnydd	SH74	SH7046	2	3	2	2

County	10km square	Tetrad	1999 min	1999 max	2006 min	2006 max
Meirionnydd	SH74	SH7242	2	3	0	0
Meirionnydd	SH74	SH7444	1	1	0	0
Meirionnydd	SH82	SH8228	0	0	0	1
Meirionnydd	SH83	SH8238	3	4	2	2
Meirionnydd	SH84	SH8240	1	1	0	0
Denbigh	SJ14	SJ1646	1	1	0	1
Denbigh	SJ24	SJ2244	3	3	0	0
Glamorgan	SN90	SN9000	1	2	0	0
Brecknock	SN92	SN9420	2	3	1	2
Brecknock	SN92	SN9620	4	6	0	0
Radnorshire	SO15	SO1856	1	1	0	0
Monmouthshire	SO21	SO2014	0	0	0	0
Monmouthshire	SO21	SO2412	0	0	1	1
Brecknock	SO22	SO2626	0	0	0	0
	Totals		**59**	**81**	**17**	**25**

In addition to the tetrads visited above, an area of mid Wales was also visited. This was the area around Plynlymon on the Ceredigion / Montgomery borders. This area did not fall into the tetrads chosen for the 1999 survey, but had been the subject of a previous survey (Tyler and Green 1994) and subsequent informal visits. No Ring Ouzels were seen anywhere around Plynlymon or on the northern valley edges such as Hyddgen that used to hold pairs.

DISCUSSION

The rather depressing results presented here confirm a trend that has been recorded since at least the 1970's (Gibbons *et al* 1993). Whilst earlier surveys and reports (such as Tyler and Green 1994) appeared to show that declines were steeper is South Wales, this study shows that the species is declining at a similar rate across Wales (albeit with a small sample in some areas), although there are still a higher number of pairs present in North Wales, especially Meirionnydd.

A survey carried out in 1995 by CCW/Steve Parr (CCW, unpublished) overlapped on a number of tetrads. Results in 1995 were lower than in 1999, but, except in one case, higher than in 2006 (Table 2). The survey methodology only involved 2 hours per visit in each tetrad, and did not involve tape playback (though see note below) and perhaps was not rigorous enough to pick up an elusive species such as the Ring Ouzel.

A number of reasons have been put forward for these declines including afforestation and other land use change in the uplands, acidification (Tyler and Green 1994) climate change (Beale *et al* 2006), hunting and other factors on the migration routes (Burfield and de L Brook, 2005), deforestation and habitat change on the wintering grounds (Ryall and Green 1994) and human disturbance (M Shrubb pers. comm.).

Although earlier surveys such as Tyler and Green (1994) were carried out after a period of great habitat loss in the Welsh uplands due to afforestation and agricultural improvement, anecdotal evidence suggests that there has been little habitat change since the 1999 surveys. Indeed, in some areas agri-environment and other schemes may have improved some parts. However, the

Table 2. Comparison with results of tetrads that were covered in the 1995 survey

Tetrad	1995	1999 max.	2006 max.
SH6224	3	5	1
SH6622	3	8	1
SH7012	3	10	4
SH7212	3	10	0
SH7824	1	0	0
SH7828	0	2	0
SH8240	1	1	0
SH9420	0	3	2
SN9620	4	6	0
SO0214	0	0	0
SO2412	0	0	1
SO2626	0	0	0

declines continue. Human disturbance has probably increased in many, but not all, upland areas and may be a factor but there is no direct evidence for this.

If climate change is the main driver of population decline, it may be expected to see a more general decline across the range. However declines in Wales, at least in the 1980's, appear to have been patchy. It is probable that a combination of factors is causing the decline and that without a more detailed knowledge of the Ring Ouzels' ecological requirements it will be difficult to put in place conservation measures for this species.

NOTE ON SURVEY METHODS

Although the tape play back method has reportedly been used successfully in other surveys (Wotton *et al* 2002) our surveyors reported getting very little obvious response to the tape. However, the rough transect approach meant that a large proportion of the tetrad was covered, and a considerable time was spent in each tetrad. For the more mountainous tetrads 'transects' were not possible but the approach of covering the whole area within 250 metres was followed as far as possible, along with the time spent listening after tape playing. Although we had little evidence that tape playing elicited response from birds, the general approach of good coverage of the tetrad combined with a 'look and listen' survey appeared to pick up more birds than the simpler walk through method used in the 1995 survey.

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THE STATUS OF MALE BLACK GROUSE *Tetrao tetrix* IN WALES IN 2005, AND A COMPARISON WITH PREVIOUS SURVEYS

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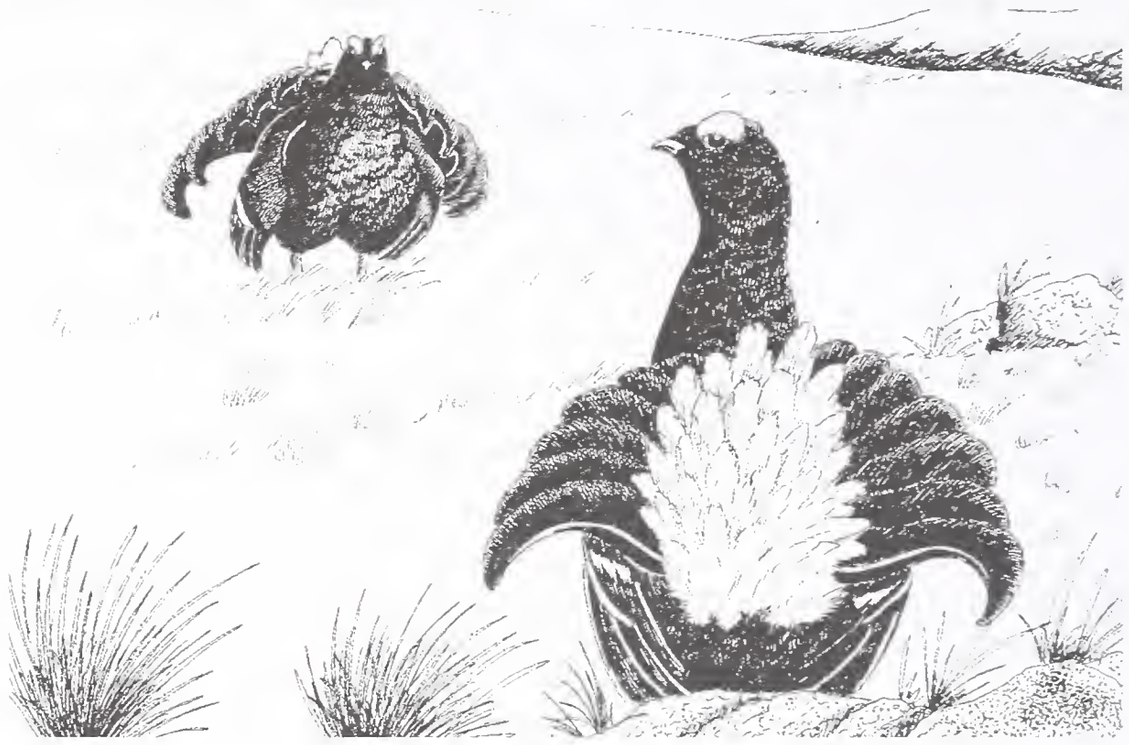

SUMMARY

1 A survey of Black Grouse in Wales was conducted in 2005 using the same method as previously, to measure population size and range, and change over time. This was part of a repeat survey of the British population.

2 There were 213 lekking males in Wales, 39% higher than during the last British survey in 1995.

3 However, more frequent surveys in Wales reveal fluctuations since 1995. Although numbers have declined by 12% since the recent high point in 2002, they remained 63% higher than the population low point in 1997. This indicates recent population recovery has been largely maintained.

4 Furthermore, between 2002 and 2005 numbers in the original six key areas, that contain most of the population, declined at half the rate elsewhere in Wales. The role of management intensity in these changes is discussed.

5 Range has continued to decline and is now just 17 10km squares, six squares less than 2002.

6 Black Grouse remain vulnerable in Wales. The BAP range target of 22 10km squares by 2010 will be difficult to achieve. However, the BAP population target of 270 lekking males by 2010 is more achievable as long as intensive conservation management targeted to key areas is continued.

INTRODUCTION

Black Grouse (*Tetrao tetrix*) were formerly widespread across much of upland Wales, with the species' geographical range probably most extensive between the end of the nineteenth century and the 1950s (Hope-Jones 1989). The population declined slowly from the 1960s onwards and rapidly in the early 1990s (Williams *et al* 1997). These declines are thought to be attributed, as in other parts of Britain, to large-scale habitat degradation and fragmentation caused by economic pressure to intensify farming and other land uses (Baines & Hudson 1995) and maturation of upland conifer plantations (Cayford *et al* 1989, Pearce-Higgins *et al* 2006). An additional factor may be changing patterns of temperature and rainfall that are known to influence breeding success (Summers *et al.* 2004).

The species is on the red list of Birds of Conservation Concern in Wales (Thorpe & Young 2002) and the UK (Gregory *et al.* 2002) owing to the rapid decline (>50%) in the breeding range over the last 25 years. Because of this, it has been listed as a species of Principal Biodiversity Importance with an associated Biodiversity Action Plan (BAP) (Anon. 1998). As part of the RSPB/FCW/CCW Welsh Black Grouse Recovery Project, intensive conservation management took place between winters 1997/98 and 2001/02, targeted primarily within the six key areas that held 80% of the Welsh population in 1997 (Lindley *et al* 2003). The key areas are Llanbrynmair, Migneint/Dduallt, Pale, Ruabon/Llandegla, Clocaenog and North Berwyn.

In order to revise the estimate of population size and range in Wales following a period of targeted conservation management, a repeat survey was undertaken in 2002. The result of 243 spring lekking males represented an 86% increase from the low point in 1997, with increases being confined to managed areas. However, although numbers increased between 1997 and 2002, range continued to decline (Table 1).

Table 1. Surveys of Black Grouse in Wales between 1986 and 2005
These surveys all used the same method so results are comparable.

Year	No. of 1-km squares visited	No. occupied 1-km squares	No. occupied 10-km squares	No. lekking males	Reference
1986	Not recorded	68	37	264	Grove *et al.* 1987
1992	Not recorded	94	34	210	Williams *et al.* 1992
1995	Not recorded	75	26	153	Williams *et al.* 1995
1997	Not recorded	60	21	131	Williams *et al.* 1997
2002	266	95	23	243	Lindley *et al. 2003*
2005	338	87	17	213	This study

After 2002, conservation management continued to be targeted in the original six key areas in a second period of recovery work, although work was at a lower intensity (annual extent of management per unit area). In an attempt to maintain range, the remaining areas that contained birds elsewhere in Wales also received some conservation management. However, management intensity was lowest in these areas due to limited resources.

In 2005, the Welsh Black Grouse population was included in the UK Black Grouse survey, part of the Statutory Conservation Agency/RSPB Annual Breeding Bird Survey (SCARABBS) programme, which surveys high priority birds every ten years. For the UK, this had two objectives: 1) to revise the estimate of population size and range, and 2) to assess the change in population size and range since previous surveys. In Wales, a third objective was to assess change during the second period of the Black Grouse recovery project.

METHODS

Sampling design

In Wales, the survey unit was the 1km square, in contrast to England and Scotland, where the survey unit was the 5km square (Sim *et al* in press). This was to ensure consistency with previous Black Grouse surveys in Wales. The survey was designed to estimate the number of displaying males in Wales using complete coverage in the six key areas (stratum 1) and recently or historically occupied sites outside key areas (stratum 2), combined with sample coverage where range expansion was most likely (stratum 3) (Table 2). Stratum 3 was defined as suitable habitat (where heather-dominated moor, upland forest and marginal farmland occur together) within 5-km of the key areas and any 2002 survey record outside the key areas, and this was randomly sampled.

Table 2. Survey design, coverage of 1km squares and numbers of lekking Black Grouse found in each stratum in 2005

Stratum	Method	No. available	No. selected	No. visited	No. occupied	No. of lekking males
1 Original six key areas	Full coverage	170	170	170	79	186
2 Recent & historically occupied squares outside original key-areas	Full coverage	118	118	118	12	27
3 Squares with suitable habitat within 5-km buffer (see text)	Random sample	356	60	60	0	0
Total		**644**	**348**	**348**	**91**	**213**

Field methods

Black Grouse are elusive except when males are displaying at leks, which they do either alone or communally. Because of this, counts of lekking males in spring is used to measure population size and range (Cayford & Walker 1991, Gilbert *et al.* 1998).

In order to ensure comparability between surveys, field methods used for counts in 2005 were the same as those used in previous surveys. Visits were made between 15 April to 15 May, the period when display and courtship by lekking males is most conspicuous (Gilbert *et al.* 1998). Counts were timed to take place between one hour before and one hour after sunrise when the weather was dry, calm (<Beaufort force 3) and with good visibility (Cayford & Walker 1991). Due to time and resource constraints, observers made only one survey visit to all 1-km squares, consistent with previous Welsh surveys. The exception to this was if the weather deteriorated during counts, or if coverage was incomplete. In such cases, affected squares were resurveyed, and the maximum count was used, consistent with the survey method in both Wales and UK. However, for 1-km squares with no recent records or random squares with suitable habitat, preparatory visits were made to identify suitable habitat and survey routes. Surveyors were instructed to use a combination of walking within 300m of all points and scanning suitable

habitats (moorland, forest and marginal farmland) within each 1-km square. Squares in all strata were visited in random order to minimise regional bias in the detectability of lekking males.

Observers took care to minimise disturbance during visits and provided a six-figure grid reference and number of lekking males for each lek found. Surveyors were also asked to record any Black Grouse seen outside selected survey squares. Although effort in these places was non-systematic and probably varied between observers, recording in this way was consistent with previous surveys. Permission to enter private land was sought where necessary. Survey work was carried out by volunteers and paid fieldworkers.

Calculation of population estimates

The population size for strata 1 and 2 was calculated as the sum of lekking males counted in each stratum. The population size for stratum 3 was the count of birds divided by the number of squares visited multiplied by the number of squares with suitable habitat.

RESULTS

Population size

Coverage was complete for selected survey squares (Table 2). There were 213 lekking males in Wales in 2005, with 186 (87%) recorded within stratum one (original six key areas), and 27 (13%) in stratum two (elsewhere in Wales). No lekking males were recorded in stratum three (area most likely to be recolonised).

Trends in population size

Compared with previous estimates obtained using the same method, there were 39% more Black Grouse in Wales in 2005 than during the last UK survey in 1995. However, Black Grouse have been surveyed more often in Wales than in the rest of the UK, and their results show a fluctuating population over the last decade. Although numbers lekking in 2005 were 63% higher than at the population's low point in 1997, the results for 2005 were 12% lower than the highest numbers in 2002 (Fig 1). However, numbers in the six key areas declined by 10% compared with a 18% decline elsewhere in Wales since 2002.

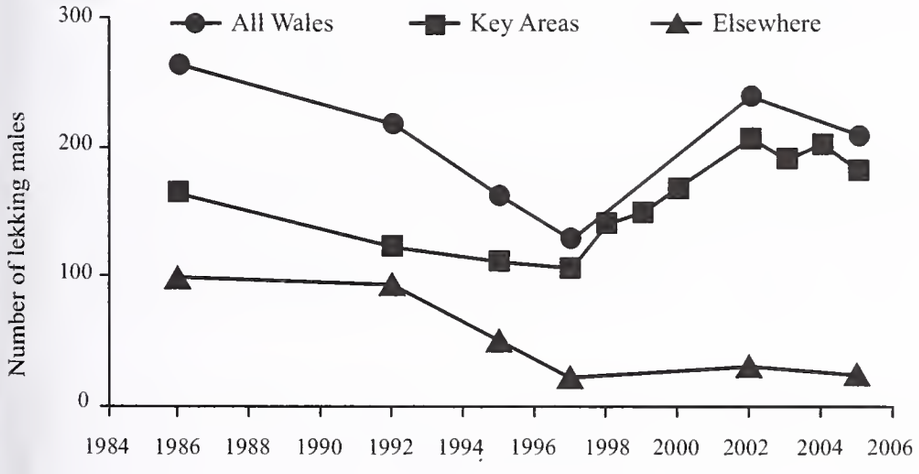

Figure 1. Numbers of lekking male Black Grouse in Wales in successive surveys. *Data are also shown for the six key areas and elsewhere in Wales.*

Trends in lek attendance

The mean lek size in key areas was 2.19 (n=85) compared with 2.08 (n=13) elsewhere in Wales. These were low compared with other UK countries and regions in 2005 (Sim *et al* in press), but were similar to that since 1995 in Wales (Lindley *et al* 2003). In key areas, 52% of leks were of solitary males (n=85), similar to previous years, while elsewhere 33% lekked alone, which was much lower than in 2002.

Trends in range

The number of 1-km squares occupied in 2005 was 27% higher than that in 1986, 45% higher than in 1997, but 8% fewer than in 2002 (Table 1). However, even within key-areas Black Grouse are patchily distributed, and their range is best assessed at a coarser spatial scale, such as 10kmx10km squares (e.g. Sharrock 1976, Gibbons *et al.* 1993). In 2005, lekking males were recorded in 17 10km squares. This compares with 65 and 40 squares in the 1968-72 and 1998-91 BTO atlases (Sharrock 1976, Gibbons *et al.* 1993) and 23 squares in 2002 (Table 1). Therefore, range has declined consistently between two BTO atlases and six successive all Wales surveys and is now at its' lowest point.

In 2005, Denbighshire held the highest number of lekking males by a considerable margin (Table 3). Black grouse lekking in Meirionnydd showed the largest decline in numbers since 2002, while Flint was the only vice county in which numbers increased (Table 3). They have become extinct in Caernarfon since 2002.

Table 3. Numbers of lekking male Black Grouse by vice county in each all Wales survey

County	1986	1992	1995	1997	2002	2005
Caernarfon	8	14	5	5	3	0
Denbigh	69	54	51	45	121	115
Flint	0	5	5	0	14	19
Ceredigion	12	13	5	0	0	0
Meirionnydd	152	122	78	64	80	61
Montgomery	16	10	20	17	25	18
Brecon	1	0	0	0	0	0
Carmarthen	6	1	0	0	0	0
Total	**264**	**219**	**164**	**131**	**243**	**213**

DISCUSSION

Survey coverage

All 1km squares selected for visits were subsequently surveyed within the dates, times and weather conditions required to be consistent with previous surveys. Therefore, the survey results were of similar accuracy and fully comparable with previous population estimates.

There was evidence from the 2002 survey that some recovery in numbers had taken place. Because of this and the possibility of subsequent range recovery, the area within 5km of key areas and other recently occupied 1km squares was surveyed. No leks were found in this stratum. Any marked range recovery would have been detected by this sampling intensity, so it is unlikely to have taken place.

One aspect of the survey method used in Wales is to record, on an *ad hoc* rather than systematic basis, any lekking birds in 1km squares adjacent to those squares initially selected for survey. Leks often change location over time (Lindley *et al* 2003), and because all 1km squares with recent or historic records were visited during each survey, the number visited, and therefore survey effort, has increased each time the survey has been repeated (although the number visited was only recorded since 2002). However, this would have made no difference for the six original key areas which, since 1997, received full coverage, and the small numbers elsewhere in Wales suggest that this increased effort would not have influenced the totals greatly.

Trends in numbers

The Welsh Black Grouse population rapidly declined between the 1980s and 1990s. This decline is likely, as elsewhere in the UK, to be linked to the maturation of upland forests (Pearce-Higgins *et al* 2006), changes in land-use leading to the fragmentation and degradation of semi-natural upland habitats (Baines & Hudson 1995, Calladine *et al* 2002), and perhaps other factors linked to these, such as predation and interactions between habitat condition and predation.

Between 1995 and 2005, numbers increased in Wales in contrast to widespread declines in the rest of Britain (Sim *et al* in press). Within Wales between 1997 and 2002, numbers increased in key areas, while elsewhere they continued to decline (Fig 1). This was coincident with the first period of the Black Grouse Recovery Project, which implemented intensive targeted conservation management (Lindley *et al* 2003). This management created favourable habitat for Black Grouse by reducing tree densities, particularly along the forest edge and moorland, cutting heather and reinstating wet areas for chick foraging.

However, between 2002 and 2005 the number of lekking males declined by 10% in the six key areas and 18% elsewhere. Previous studies of habitat selection by Black Grouse in the UK have shown a strong affinity for woodland edges that are rich in heather *Calluna vulgaris* and bilberry *Vaccinium myrtillus* (Picozzi & Hepburn 1984, Cayford 1990), or large areas of heather moorland (Parr & Watson 1988). Without management, vegetation succession in these areas can make favoured food plants scarce, and Black Grouse may depend on disturbance through, for example, natural episodes of fire, tree falls, and grazing, to maintain patches of these habitats in favourable condition. This hypothesis fits with the documented association between Black Grouse and habitats that are in succession from open moorland to forest (Johnsgard 1983, Klaus 1991).

Therefore, one explanation for the population decline between 2002 and 2005 is the lower intensity of habitat work in key areas since 2002 and minimal management elsewhere. Black Grouse population growth rates may be particularly sensitive to the availability of food plants, and this reduction in management intensity may have been sufficient to halt population growth. However, there were differences in habitat composition, types of management and predator control status between managed areas and time-periods, and on its own, these results are insufficient evidence to link conservation management with population recovery. Separate analyses of long-term monitoring of conservation management, breeding success and lek counts within key areas are underway to determine whether the onset and intensity of management and population recovery are indeed linked.

Alternatively, key area counts have fluctuated since 2002, and the observed decline since 2002 is only marginally outside the observed range of between-year differences for key area totals (6-10%), which could be due to survey error. Future surveys will help discriminate between this and a continuing decline.

Lek size and the percentage of leks with single birds have remained stable within key areas since 1995. Therefore, there is no evidence that the population changes since 1997 have brought about changes in patterns of lek attendance.

Trends in range

Whilst Black Grouse have increased in number since 1995, survey results show their range is continuing to decline (Fig 2), with some small isolated populations becoming extinct since 2002. Male dispersal distances are very small (Warren & Baines 2002), and this will make natural recolonisation unlikely once isolated populations have been lost.

Achieving the BAP targets

Black Grouse are part of upland ecosystems and this naturally limits their range. These ecosystems have changed dramatically over the last two centuries through agricultural intensification and afforestation (Storch 2000). They may be expected to undergo further alterations through the effects of climate change (Ludwig *et al.* 2006).

The Welsh Black Grouse BAP has targets for both numbers and range. If and how these are met requires decisions about use of limited resources for conservation. For example, there are arguments for maintaining range in all places, because natural recolonisation will be very slow or absent. However, in small populations isolated from key areas, even conservation management of a much higher intensity than implemented in this study may not sufficiently reduce extinction probability in the face of stochastic effects such as weather. Therefore, the pragmatic approach of maintaining key areas in favourable condition, where the extinction probabilities are currently lowest and intensive conservation management is easier to justify, has been adopted for the next five years (2007-2012).

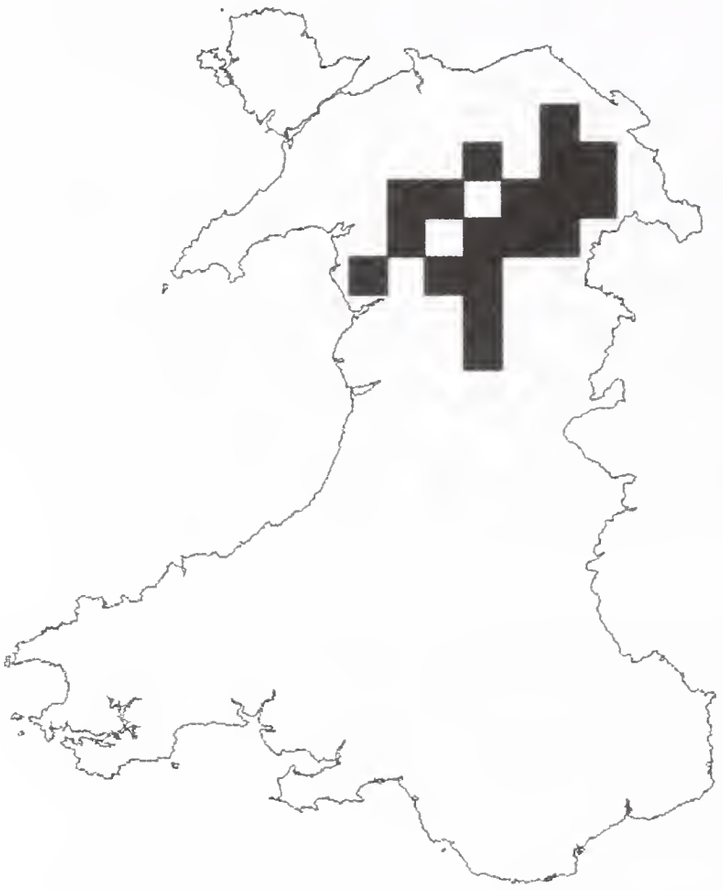

Figure 2. The distribution of Black Grouse in Wales in 2005, based on occupied 10-km squares. *For comparison, distribution in 1968-72, 1988-1991 and 2002 can be found in Lindley et al (2003)*

The BAP targets for overall Black Grouse numbers in Wales will not be met without further action in three areas. First, research to conclusively link the population change since 1997 with conservation management, to increase confidence in the prescriptions used. Second, continuing to implement these prescriptions at a high intensity within key areas as part of species recovery projects. Third, work to incorporate these prescriptions at the required intensity into agri-environment schemes and commercial forestry systems to ensure management continues beyond the life of the recovery project.

Meeting the BAP targets for range is problematic. Recolonisation may take place naturally over many years, but targets will be missed. It could happen more quickly using translocations, but these are unproven and could dilute resources away from maintaining numbers in the key-areas.

ACKNOWLEDGEMENTS

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THE DIET OF THE LITTLE OWL *Athene noctua* ON SKOMER ISLAND

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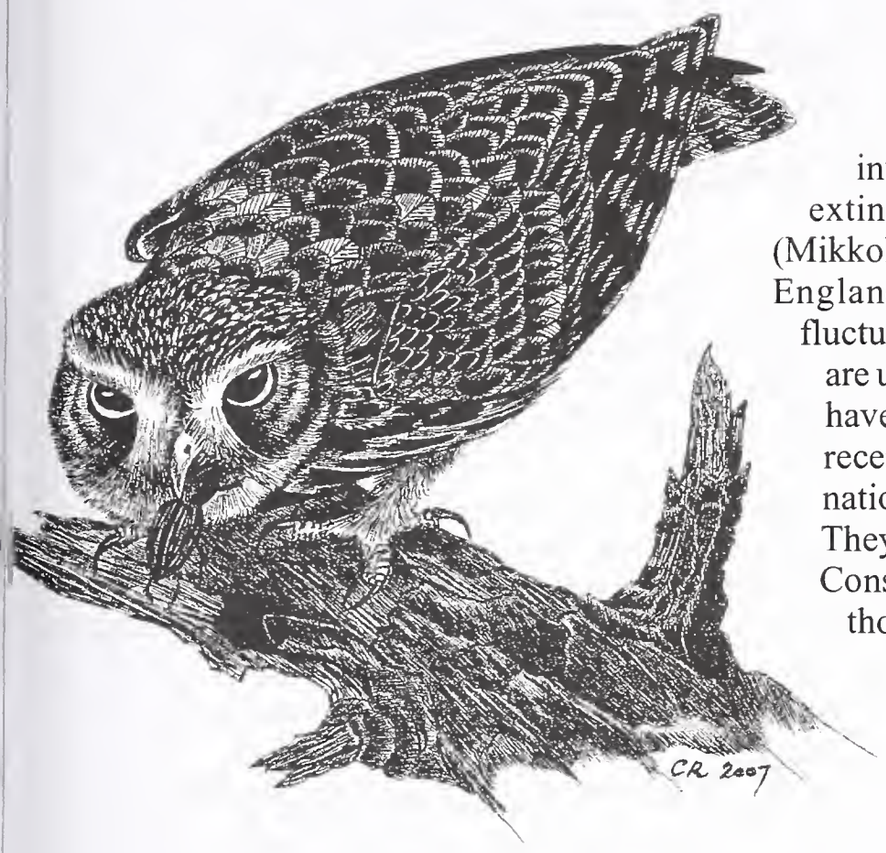

INTRODUCTION

The Little Owl was re-introduced into Britain in 1843, after its probable extinction during the last glaciation (Mikkola 1983), and is now widespread in England and Wales, though numbers fluctuate and long term population trends are uncertain (BTO 2006). They appear to have declined considerably in Wales in recent years (Pers Obs), although the national trends are unclear (BTO 2006). They are also a Species of European Conservation Concern (SPEC3). They are thought to have colonised Skomer and Skokholm in the 1920s, though they were removed from Skokholm in 1954 due to worries about Storm Petrel (*Hydrobates pelagicus)* predation (Hayden 2006).

Concern about the effects of Little Owl predation on Storm Petrel led to a project, commissioned by the Countryside Council for Wales (CCW) in 2004, to look at the diet of Little Owl on Skomer island, building on the already extensive work of Hayden (2006).

The full results of the project are reported elsewhere (Green *et al* 2006). This paper summarises the results of a literature review of Little Owl diet, and an analysis of Little Owl diet from pellets collected on the island.

METHODS

Literature review

A review was carried out using standard search engines and following up references in papers.

Pellet analysis

Pellets were collected from a variety of locations on the island between May and September 2004. Pellets were located by observing owl roost sites and from knowledge of roosts provided by island staff. When found pellets were bagged and labelled with the date and location of collection. 87 pellets were collected and were analysed using the methods described by Yalden (2003). Pellets were classified by their main matrix (the core content binding the pellet together, such as fur or feather), then slowly teased apart and carefully examined, with a magnifier where

necessary. The contents were then identified using standard keys, a reference collection and expert consultation.

RESULTS

Literature review

There is surprisingly little published information concerning the diet of Little Owls in Britain. The most recent publication is the work done on Skomer by Hayden (2006) between 1998 and 2003 on which this study builds. A paper on the diet of Little Owls in Gloucestershire (Hounsome *et al* 2004) points out that despite their widespread distribution most data from British studies come from the early 20th century (eg Collinge 1922 and Meade-Waldo 1912) and the Little Owl food enquiry (Hibbert-Ware 1937). More recently there has been one study in Derbyshire (Altringham *et al* 1994). Only two recent studies from elsewhere in their range were found, one from Greece (Goutner and Alivazatos 2003) and one from Egypt, Syria and Iran (Obuch and Kristin 2004).

From this literature it is clear that Little Owls take a wide variety of prey items including: invertebrates, amphibians, reptiles, birds including passerines, Storm Petrels and waders, small mammals such as bats, voles and mice, and larger such as rats and rabbits. In all studies invertebrates formed a large proportion of the diet, with other components varying according to location.

As Little Owls have such a catholic diet and are obviously opportunistic feeders diet is going to vary according to location. For example, in the Gloucestershire study earthworms were found in 97.4% of the pellets, whereas none were found in the Skomer study. Birds form a reasonable proportion of the diet in other UK studies (15% frequency of occurrence in Gloucestershire (Hounsome *et al* 2004) and 18% in the study by Collinge (1922)). The Skomer study found between 1.72 and 2.6% of total prey items were birds in 2002 and 2003 (Hayden 2006) with between 1.47 and 1.2% of prey items being Storm Petrel. However, when converted into biomass the importance of Storm Petrel in the diet increases to between 26.7 and 13.9% of the diet. In other studies passerines appear to be the main type of bird taken in the UK, and Hayden (2006) also found Meadow Pipits (*Anthus pratensis*) as prey items on Skomer. We could find no other record of Storm Petrels as prey items in the recent literature, however this reflects the location of the studies rather than prey selection by the owls.

Table 1. Main contents of Little Owl pellets from Skomer

No. of pellets	Main matrix	Notes
32	Beetles	5 contained some mammal bones, the rest were purely beetle remains.
13	Fur / beetle	
10	Fur	
19	Feather	1 small passerine, 2 containing possible shearwater feathers, 16 containing petrel remains.
13	Vegetation	Contents mixed but mainly bits of vegetation. No signs of earthworms were found.

Pellet analysis

The majority of the pellets, as found in other studies, contained insect remains, mainly various species of beetle. Over a third of the pellets contained only beetle remains. Over a quarter contained mammal remains and Woodmouse (*Apodemus sylvaticus*), Skomer Vole (*Clethrionomys glareolus skomerensis)* and Common Shrew (*Sorex araneus*) were identified. Nearly a quarter of the pellets contained bird remains of which the majority were thought to be Storm Petrel. One was probably a small passerine, possibly Meadow Pipit and two were possibly Manx Shearwater (*Puffinus puffinus*) feathers.

Invertebrate remains were the most numerous prey item, both in terms of main pellet matrix (36% of pellets) and in numbers. Remains of around 318 invertebrates were recorded. The percentage totals of each type of prey item are shown in Table 2.

Table 2. Totals of prey items

Prey Item	**% of total number of prey items - this study**	**% of total number of prey items - Hayden, 2006.**
Invertebrates	92.7	88.3
Mammals	4.9	4.7
Bird	1.7	1.72

67% of the invertebrates were beetles *Coleoptera*. These were made up of *Carabidae* 56%; *Geotrubidae* 31%; *Curculionidae* 12% and *Staphylinidae* 0.5%. The remaining numbers were made up of earwigs (14% of total invertebrates) and ants (17%). Of the mammals, 6 Woodmice were identified, 9 Skomer Voles and 2 Common Shrews. A minimum of 3 and maximum of 6 Storm Petrels were identified based on major bones such as skulls. As Hayden (2006) points out, when converted to biomass based on the known weights of the species identified this would leave Storm Petrel as an important part of the diet of the Lttle Owl over the part of the year they are eating them.

Several of the pellets with an insect matrix were already disintegrating at the time of collection. It is quite likely therefore that fur and feather matrix pellets were over represented in the collections as they last longer. Feather matrix pellets were particularly robust.

This study supports previous studies that show the Little Owl has a varied diet and appears to be an opportunistic feeder, taking what food is readily available. On Skomer Storm Petrels appear to form an accessible and possibly important part of the Little Owl's diet.

ACKNOWLEDGEMENTS

Thanks to Catherine Gray and Sian Whitehead at CCW for initiating and funding the project, and permission to use results. Thanks to Alistair Wilson for collecting the pellets, to Jane Hayden for much useful advice and loan of reference collection and to Skomer staff for help during fieldwork. Finally, thanks to Dave Reed for help with identification of invertebrate remains.

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BREEDING PERFORMANCE OF RAVENS *Corvus corax* IN SNOWDONIA, 1998-2005

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INTRODUCTION

The results of a population census of Ravens in six regions of north-west Wales during 1998 to 2005 have previously been presented in Welsh Birds (Driver 2006). This paper analyses the breeding performance of Ravens during the same period 1998 to 2005 for just one of these regions, Snowdonia, and also examines in detail the altitudinal effects on breeding. Long-term trends in breeding productivity are also evaluated by comparing the results with those of three previous Raven studies in the same region by Allin (1968), Ratcliffe (1997), and Dare (1986). It is intended to present and compare the breeding results for the other regions at a later date.

STUDY AREA AND METHODS

The rugged mountain massif of Snowdonia towers prominently above the surrounding regions and rises sharply from sea-level to a maximum elevation of 1085m at Y Wyddfa summit within relatively short distances of 15-20 kms. Deep glaciated valleys radiate outwards and expose numerous high crags long favoured by nesting Ravens. A more detailed description of this region was given earlier (Driver 2006). Lying just west of the winter 5°C isotherm, Snowdonia is within the hyperoceanic subsector as described by Bendelow and Hartnup (1980) and the climate is influenced by prevailing westerly, oceanic winds. As a consequence the winters are relatively mild with high levels of precipitation but summers tend to be cooler than other regions further to the east.

Figure 1. Regions of north-west Wales

First-egg dates were estimated (to within +/- 2 days) from incomplete clutches (using a laying interval of one day per egg) and by backtracking from known hatching dates (using 21 day egg period). Where possible nest contents were checked at least twice during both the egg and brood stages followed by a final visit near the predicted fledging date.

In order to minimise the 'observer disturbance effects' on the study results, particular care was taken to reduce the amount of time taken when examining nest contents during the clutch and early brood stages. All nests were therefore visited by free climbing without the use of ropes and by using planned routes in and out of the nest sites. Most sitting birds were only kept off their nests for less than 15mins and if a sitting bird was accidentally flushed during the approach stage or if there were other potential disturbances in the vicinity, such as climbers or hill walkers, observations of the nest would be postponed.

RESULTS

During the eight-year study period, 1998-2005, a total of 161 occupied Raven territories were monitored and nest data were collected in 151 territories. Eighty-eight nesting pairs were monitored particularly closely and in greater detail.

Nest sites

Many Raven nest sites in Snowdonia are known to have been in existence for at least fifty years, and probably considerably longer, as is often betrayed by old Welsh place names like Craig Nyth Gigfran, Carreg y Gigfran, Clogwyn Cigfran and Carreg Fran. Such locations are still occupied by Ravens to this day.

The altitudinal range of 198 nests were surveyed and a substantial difference was found between the lowest nest (10m) at Abergwyngregyn and the highest nest (790m) on Pen yr Ole Wen above the Ogwen valley. The majority of Snowdonia Ravens (88%) build their eyries on well-protected rock ledges on high crags or in quarries and 10% use trees, especially conifers (Driver 2006). Just occasionally Ravens build nests in more unusual situations. One such nest was found on a very steep, exposed mountainside just below a 623m summit. The slope had scattered shale outcrops and was heavily vegetated with Woodrush (*Luzula* sp.), Soft Rush (*Juncus effusus*) and Mat Grass (*Nardus stricta*). This nest was well hidden amongst the vegetation and essentially on the ground, being a 'walk-in job'. A similar nest on a sloping woodrush-covered bank on Orkney has previously been documented (Ratcliffe 1997).

The overall mean altitude of nests was 330m. The majority (76%) of nests were situated between 100-500m with only 19% of nests at altitudes above 500m and 5% below 100m (Table 1.). In a few territories there was considerable altitudinal spacing of alternative nests, the largest being 200m for alternative nests in a territory on Craig Ysgolion near Bethesda.

Table 1. Altitudinal ranges for Raven nests in Snowdonia

Altitude	Number of nests (%)
501 - 800m	38 (19)
301 - 500m	67 (34)
101 - 300m	84 (42)
0 - 100m	9 (5)

Of Ravens nesting on cliffs or crags, 68% of pairs had 2-4 alternative nest sites available but usually just one principal nest (Table 2), and 14% had 5-7 alternative nests though many of these were merely nest remnants existing in sheltered situations that had been in use prior to 1998. Of the few (18%) pairs with no obvious alternative nest, most were tree nesters whose alternative nests (if any) had probably been destroyed during gales Individual nests were also often used repeatedly over many years. In Snowdonia, the longest use of a nest was for 15 consecutive years, and two other pairs used the same nests for 9 and 8 successive years. Allin (1968) mentions a nest on the Carneddau, which was used for 8 successive years during his study.

Table 2. Frequency of alternative nests for 50 regular breeding pairs of Ravens in Snowdonia

Number of alternative nests	Number of pairs
0	9 (18%)
1 to 4	34 (68%)
5 to 7	7 (14%)

Egg-laying dates

Egg laying was recorded over an 8-week period, with extreme first-egg dates of February 16th and April 12th (Table 4). Nearly half (49%) of Ravens layed during the first half of March and the median first-egg date was March 10th (Table 4). In 15% of nests the eggs were laid during the second half of February (Table 3). There was no evidence of repeat clutches having been laid by any pairs during the study period.

Table 3. Distribution of 1st-egg dates for 74 Raven pairs in Snowdonia, 1998-2005

	Number of nests
February (second half)	11 (15%)
March (first half)	36 (49%)
March (second half)	21 (28%)
April (first half)	6 (8%)

A statistically significant relationship was found between nest altitude and the start of egg laying (Table 4, Fig. 2). There was a progressive delay in the median 1st egg dates with increasing altitudes, from March 5th for nests below 100m to March 29th for nests above 500m. Interestingly, both the earliest and latest egg-laying dates occurred among pairs nesting at 350m.

Table 4. Altitudinal distribution of mean first-egg dates in 74 Raven nests in Snowdonia, 1998 - 2005

Altitudinal range (metre)	Number of nests	Median First-egg dates	Range of dates
501 - 700	5	March 29th	Mar. 10th - April 10th
301 - 500	28	March 16th	Feb. 16th - April 12th
101 - 300	36	March 7th	Feb. 23rd - April 1st
0 - 100	5	March 5th	Feb. 21st - March 29th
0 - 700	74	March 10th	Feb 16th - April 12th

On average egg laying was delayed by 3.6 days for every 100m increase in altitude (Fig. 2). There was a wide spread of first-egg dates at each altitude. Though it is possible that some of the exceptionally late dates could relate to repeat clutches, there was no evidence to support this. A similar correlation was also found for Ravens in Northern England and Southern Scotland (Ratcliffe 1997) and for Carrion Crows (*Corvus corone*) in the Carneddau region of Snowdonia (Driver 2005).

There was no evidence of Ravens laying repeat clutches, following the failure of a first clutch, despite regular checks of many failed nesting territories. In fact, over the past thirty years I have only recorded one definite repeat clutch, which was during 1994. This was at a Snowdonia nest where an early clutch had disappeared from a crag nest and the birds subsequently re-laid in a nearby old Buzzard *(Buteo buteo)* nest in a Silver Birch (*Betula pendula*) and successfully reared one youngster. There have been other occasions at other nest sites where I had initially suspected repeat clutches having been layed in near by alternative nests but these subsequently all proved to be closely spaced nesting pairs or involved bigamous birds. During two previous Raven studies, Dare (1986) noted only one definite repeat clutch in Snowdonia while in North Wales two were observed by Allin (1968).

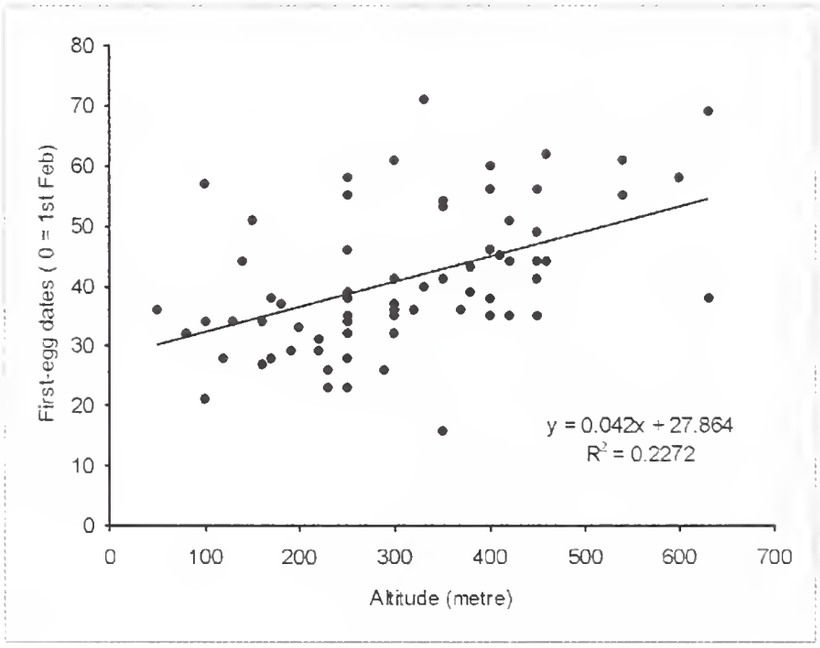

Figure 2. Relationship between first egg dates and nest altitude for Ravens in Snowdonia, 1998-2005
n=74 clutches

Clutch Sizes

Clutch sizes for 79 complete layings ranged from 3 to 7 eggs with an overall mean of 4.9 eggs (Table 5), which agrees with that found during a previous study of this population during 1978-84 (Dare 1986). Annual mean clutch sizes varied between 4.7 - 5.3 eggs throughout this study period, for which there were no obvious reasons, though sample sizes were very small in some years. The modal clutch size was 5 eggs (47% of nests) while an almost equal number of pairs laid clutches of 4 eggs (22%) or 6 eggs (23%). All the 3-egg clutches were considered to be complete. Exceptionally, one female laid a 7-egg clutch.

Table 5. Raven clutch sizes in Snowdonia, 1998 - 2005

Years	Total Nests	Clutch Sizes					Mean Clutch Sizes
		Three	Four	Five	Six	Seven	
1998	12	1	1	9	1		4.8
1999	6	1		4	1		4.8
2000	16		3	9	4		5.1
2001	3		2		1		4.7
2002	9		3	4	2		4.9
2003	17	4	1	5	7		4.9
2004	4		2		1	1	5.3
2005	12		5	6	1		4.7
Total Nests	79	6	17	37	18	1	4.9
(%)		(8)	(22)	(47)	(23)	(1)	

Table 6 suggests that there were also distinct altitudinal effects on clutch sizes in Snowdonia. The average clutch sizes were 15% smaller (4.4 eggs) at 500-700m than below 300m (5.2 eggs).

Table 6. Altitudinal variation of clutch sizes in 78 Raven nests in Snowdonia, 1998 - 2005

Altitudes	Total Nests	Clutch Sizes					Mean Clutch Sizes
		Three	Four	Five	Six	Seven	
500m - 700m	8	1	3	4	0		4.4
300m - 500m	42	4	10	20	7	1	4.8
100m - 300m	29	1	4	13	11		5.2
Total Nests	79	6	17	37	18	1	4.9

Brood Size at Fledging

A mean of 2.4 young fledged from successful Snowdonia nests during the 8-year period (Table 7); similar to the value of 2.6 found for the same region during 1978-84 (Dare 1986). Annual variations were slight, amounting to only 0.3 chicks. Most of the successful pairs (63%) produced 2 or 3 fledged young though a substantial number (21%) only managed to rear a single

fledgling. Fledged broods of 4 young were relatively uncommon (14%) and only 9 pairs (2%) fledged five young (Table 7). The pair that fledged 6 youngsters was at a quarry nest in the Nantlle Valley during 2000. The high productivity of this pair was almost certainly due to the close proximity of an active refuse tip, which provided excellent scavenging opportunities. The only other record of a six-brood nest in North Wales was one found during 1946-67 by Eric Allin although he does not mention if they all fledged successfully (Allin 1968).

The earliest and latest known fledging dates were about April 21st and June 24th respectively, and a mean fledgling period of 47.3 days (range 44 - 52 days) was precisely recorded for 10 broods.

Table 7. Fledged brood sizes of 369 successful Raven pairs in Snowdonia, 1998 - 2005

Years	Total Nests	Fledged brood sizes						Mean fledged brood sizes
		One	Two	Three	Four	Five	Six	
1998	31	7	13	6	5			2.3
1999	49	12	17	14	6			2.3
2000	70	11	23	22	8	5	1	2.6
2001	24	6	8	7	3	1		2.3
2002	44	11	12	12	8	3		2.5
2003	64	14	23	17	7			2.4
2004	42	8	13	13	8			2.5
2005	45	7	19	14	5			2.4
Total Nests (%)	369	76 (21)	128 (35)	105 (28)	50 (14)	9 (2)	1 (0.3)	2.4

As with egg laying dates and clutch sizes, there was also a negative relationship between fledged brood sizes and increasing altitude in Snowdonia. Fledged broods were 23% smaller at 700m than at 100m (Table 8).

Table 8. Altitudinal distribution of fledged brood sizes for 369 Raven nests within the Snowdonia region, number of nests, 1998 - 2005.

Altitudes	Total Nests	Fledged brood sizes						Mean fledged brood sizes
		One	Two	Three	Four	Five	Six	
500m to 800m	55	19	17	18	1			2.0
300m to 500m	143	34	52	36	17	4		2.3
100m to 300m	171	23	59	51	32	5	1	2.6
Total Nests	369	76	128	105	50	9	1	2.4

Breeding Success

The overall breeding success was calculated for a sample of 211 fully monitored breeding attempts (i.e. where complete clutches were laid). Of these, 167 (79%) were successful in

rearing one or more young; similar to the 73% found during 1978-84 (Dare 1986a). Of the 44 (21%) breeding attempt failures, 21 (48%) failed during egg laying, 19 (43%) of full clutches were lost during incubation or at hatching time, and 4 (9%) failed when chicks were more than 4 weeks old.

Even among successful pairs there were losses of eggs and chicks such that only 49% of eggs produced fledged young. Losses at different stages were calculated from 51 complete clutches of known size (mean 4.9 eggs) that were regularly inspected. For these there was a loss of 1.7 eggs (35%) during incubation or of chicks within a few days of hatching. Thus, the mean brood size for chicks more than one week old was 3.2. Of these, a further 0.8 chicks per brood died before fledging. Comparison of the mean clutch (4.9) and fledged brood (2.4) sizes indicates a mean loss of 2.5 eggs (51%) per clutch.

Fatalities amongst feathered chicks were found to be minimal with only about 6% loss of chicks more than 2½ weeks old. One of the most frequent causes of fatality amongst older chicks prior to fledging was due to their feet becoming entangled in brightly coloured baling twine with which the adults like to decorate their nests. I recorded ten such occasions when large youngsters, at the fledging stage, were found snared on their nests and all eventually died, probably due to starvation having been abandoned by their parents. This plastic twine is also favoured by other *Corvids* for decorating their nests and similar fatalities of youngsters have been recorded at several Carrion Crow and one Chough *(Pyrrhocorax pyrrhocorax)* nest.

Throughout the eight year study period, the occupancy and breeding success of Ravens in most occupied territories was established and it was found that 82% of pairs attempted to breed (i.e. laid eggs) but that 17% of these breeding attempts failed completely (Table 9). No nesting was attempted in 19% of occupied territories although it was possible that early in the season some failed nests may not have been detected. Further analysis showed that the breeding performance and productivity of birds in new territories was very similar to that in long established territories.

Table 9. Number (%) of successful, failed & non-breeding Raven pairs in Snowdonia and mean number of young fledged per territorial pair, 1998-2005

Years	Number of territorial pairs	Non-breeding pairs	Failed pairs	Successful pairs	Number of young fledged	Mean young fledged
1998	47	2 (4)	14 (30)	31 (66)	71	1.5
1999	72	10 (14)	13 (18)	49 (68)	112	1.6
2000	114	21 (18)	23 (21)	70 (61)	186	1.6
2001	36	11 (30)	1 (3)	24 (67)	55	1.5
2002	74	16 (22)	14 (19)	44 (59)	108	1.5
2003	92	12 (13)	16 (17)	64 (70)	154	1.7
2004	64	20 (31)	2 (3)	42 (66)	105	1.6
2005	73	16 (22)	12 (16)	45 (62)	107	1.5
Totals	572	108 (19)	95 (17)	369 (65)	898	1.6

Based on an annual productivity of 1.6 fledged young per territory (Table 9) and a minimum of 169 territorial pairs of Ravens located during the population census of Snowdonia, 1998-2005

(Driver 2005), the total productivity averages 270 fledglings per year. However, it is probable that post-fledging mortality would greatly reduce this number during the first year.

DISCUSSION

The first Raven study for Snowdonia was undertaken by Eric Allin (1946-67) who presented detailed breeding information, particularly with regard to the altitudinal influences on breeding performance. He covered the eastern half of Snowdonia but included nest data from other upland regions of north Wales in his final summary. Consequently it was not feasible to make any direct comparisons with his results. Allin's study was closely followed by similar survey work by D. A. Ratcliffe (1951-79) and P. J. Dare (1978-84) both of whom covered the whole of Snowdonia but concentrated on the distribution of breeding pairs and only presented incidental details of breeding performance. Neither Ratcliffe or Dare gave figures for mean clutch sizes but they both recorded matching mean fledged brood sizes of 2.5 young which are "virtually identical" to the 2.4 young found for all altitudes during this study.

The retarding effect of altitude on egg laying was documented for northern England & southern Scotland by Ratcliffe (1997) and in North Wales by Allin (1968) but only for nesting pairs above and below 1000 ft. The present study examined these altitudinal effects on breeding performance in more detail and for the smaller region of Snowdonia. The findings of both Ratcliffe and Allin were not only corroborated during this new study but there were also corresponding decreases in both clutch and fledged brood sizes with increasing altitudes. Neither Allin nor Ratcliffe had found any such altitudinal changes though Allin had noted a slight decrease in mean brood sizes from 3.37 to 3.12 for nesting pairs below and above 1000 ft in north Wales

There is little doubt that the current prosperity of the Snowdonia Ravens is in part due to the excellent scavenging opportunities found on the Snowdonia sheep pastures, assisted by considerably increased sheep stocks during the past fifty years. For example, during 1952-92 stocks of breeding ewes increased by 48% on Carneddau massif and for all of Snowdonia between 1976-93 there was a 29% increase (Ratcliffe 1997). This helps to explain why new pairs performed as well as long established pairs. However, recent changes in stock management of hill-sheep could influence the future breeding performance of Ravens in Snowdonia. Fewer sheep are now wintered on the mountain grasslands and it is common practice by many hill-farmers to transport mountain ewes to lowland pastures beyond Snowdonia from November through to April. This greatly reduces potential scavenging opportunities for the high altitude Raven pairs during winter and early spring. This may affect the breeding condition of female Ravens leading to later nesting and difficulties in providing sufficient food for large broods.

There was no evidence to suggest that the rapidly increasing Raven population and consequential reduction in nest spacing that occurred during the study period (Driver 2006) had any effect on breeding performance. During the eight years 1998-2005 there were only small variations in overall breeding productivity of between 1.5 - 1.7 young per territorial pair and the combined proportion of failed and non-breeding pairs varied little between years from 30-41% (Table 9). In part, this stability in breeding performance was probably assisted by a succession of mild winters with insignificant periods of snow cover. It was therefore not possible to evaluate the effects of a severe winter on breeding performance. During a previous Snowdonia Raven study 1978-85 there had been a higher success rate for nesting Ravens following the moderately severe winter of 1979 which was attributed to higher than normal sheep mortality and greater

scavenging opportunities (Dare 1986a).

The effect of food availability on the number of breeding pairs and productivity was well illustrated at a quarry complex where there was a working refuse tip. During 2000 there were 8 territorial pairs established within a 2½ km radius of this refuse tip. Of these, 5 pairs successfully fledged 17 young (including one pair which fledged 6 young), one pair had a failed clutch and another pair built a nest by the refuse tip but did not lay eggs. An eighth non-breeding pair was also present. During the following years 'bird scares' were used at the refuse tip in order to disperse huge numbers of scavenging Gulls but which also reduced the feeding opportunities for local Ravens. During 2003, only 3 pairs nested of which one pair had a failed clutch and of the 2 successful pairs only 3 young were fledged. Of the original eight sites, three have now been abandoned.

Human persecution of Ravens in Snowdonia was considered to be minimal and only two nest sites were known to have been regularly targeted by farmers, which were on the eastern fringes of the study area. Within the main core of Snowdonia human disturbance of nesting Ravens from the many visitors to the National Park was minimal and, in fact, many Snowdonia Ravens have now become remarkably tolerant of human activities. For example, a pair on Clogwyn y Grochan, near Llanberis, has nested successfully for many years on what is probably one of the busiest and most popular climbing walls in all of Snowdonia. At another nest site, in the Nant Ffrancon, a Raven was seen scavenging from sheep carcasses dumped in a working farmyard and carrying food back to a nest with large young on a small crag less than 900m from the farm. During an examination of this same nest, but earlier in the season, the sitting bird was flushed off a complete clutch of eggs to which she returned immediately as I began to vacate the site but was still within 10m of the nest. There is little doubt that the reduced persecution and increasing tolerance of human activities has assisted the expansion and breeding performance of Snowdonia Ravens during recent decades. A similar conclusion was also suggested during the study of another expanding Raven population in NE Wales (Roberts & Jones 1999).

It was also noted that there had been increasing numbers of non-breeding flock birds present in Snowdonia during the study period. These birds often congregate in communal areas, particularly around the summit ridges of Y Wyddfa, Craig Ysgolion and Craig Cwm Silyn, from where they mount scavenging expeditions into the surrounding areas. Counts of 50 or more birds are now a regular occurrence at these locations throughout the year and occasionally can exceed 100 birds. In comparison, during 1978-85 Dare (1986a) estimated that probably fewer than 40-50 unattached Ravens frequented Snowdonia. This increase of non-breeders might adversely affect the resident population through increased territorial skirmishes and greater competition for food within their home ranges, although there was no evidence of this.

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OYSTERCATCHERS *Haematopus ostralegus* AT TRAETH LAFAN, NORTH WALES, IN THE 1960s: BEFORE THE ADVENT OF COMMERCIAL COCKLE FISHING

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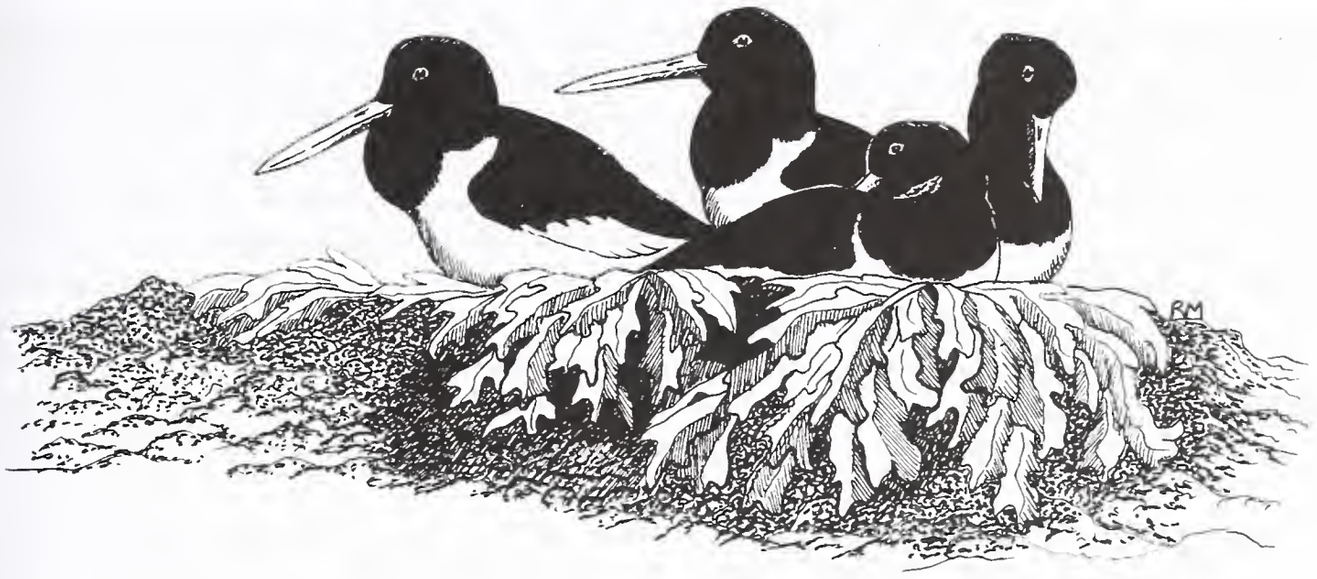

INTRODUCTION

Traeth Lafan (Lavan Sands), at the north-east entrance to the Menai Strait between Bangor and Llanfairfechan, is a Special Protection Area and part of the proposed Menai Strait cSAC. The site is particularly important in a Wales context for its large numbers of passage and wintering Oystercatchers. These feed particularly on the cockle and mussel beds but also in other intertidal habitats and adjoining fields. Before the 1980s, cockle abundance here was considered inadequate to attract significant commercial fishing. Since 1983, however, market forces and advances in fishing technology have made these relatively low level stocks more commercially attractive, resulting in heavy exploitation within a demarcated area in several recent years. The activities of modern hydraulic cockle dredgers fishing over high water, and gangs of itinerant hand gatherers raking at low tide, have raised major concerns locally (Countryside Council for Wales and others) about possible adverse effects upon dependent Oystercatchers, as well as the wider intertidal ecosystem. This has led to a desk (theoretical) study of potential impacts upon Oystercatchers commissioned by CCW (Atkinson *et al.*, 2005a). These authors attempted to interpret ringing and biometric data collected by SCAN Ringing Group at Traeth Lafan since the early 1980s, with reference to limited shellfisheries information from recent cockle fishing episodes.

Atkinson et al. (2005a, b) seem to have been unaware of earlier ringing and ecological research on the Traeth Lafan Oystercatcher population undertaken during 1963-69, long before significant cockle fishing began there. That study formed part of a wider Ministry of Agriculture Fisheries and Food research programme into Oystercatcher movements and population distribution in relation to their depredations upon cockle fisheries in the Irish Sea and South

Wales. The census and ringing results were published for Traeth Lafan and the other main wintering areas studied (Dare 1966, 1970) but those from a follow-up project at Traeth Lafan in 1966-69 were excluded. The latter aimed, by use of individually colour-coded birds, to assess the monthly population turn-over of Oystercatchers at Traeth Lafan and the degree of individual fidelity to feeding sites. The project was terminated abruptly after three years (by a policy switch to other work) and the results were not published. Given recent predictions for past and future effects of cockle fishing upon Oystercatcher numbers and survival at Traeth Lafan (Atkinson *et al*, 2005a, b), it may be timely and instructive to describe the dynamics of that population in the era before fisheries exploitation.

STUDY AREA

The Traeth Lafan intertidal zone is ca. 23 km^2 in extent and comprises predominantly sand flats exposed to vigorous wave action from N-NE winds (Figure 1). Substrates and macrofauna were described by Eagle et al. (1974) and the shorebird populations during the 1960-70s were documented by Dare & Schofield (1976) and Prater (1981). The sands sustain a large biomass of cockles in some years together with various bivalves, polychaet worms and other infauna typical of such habitats. The narrow upper shore is silty while extensive mud flats are found in the most sheltered SW sector towards Bangor. Small natural beds of mussels are present along the stony foreshore in the east at Llanfairfechan. On the Anglesey side of the Strait opposite Traeth Lafan the foreshore is typically 400m wide with a mix of weed covered stones and muddy sand ground and scattered small mussel beds. More extensive beds (45 ha) occurred on old ballast banks at Bangor Flats.

During this study period, early attempts were being made to farm mussels by relaying stocks, taken from elsewhere, onto intertidal plots on the Bangor mud flats. Since that time, a large mussel cultivation industry has developed in this part of the Menai Strait. For practical purposes during the Oystercatcher studies, the area was divided into eastern (Llanfairfechan) and western (Aber) sub-areas, either side of the Aber river outfall 'promontory' (Figure 1).

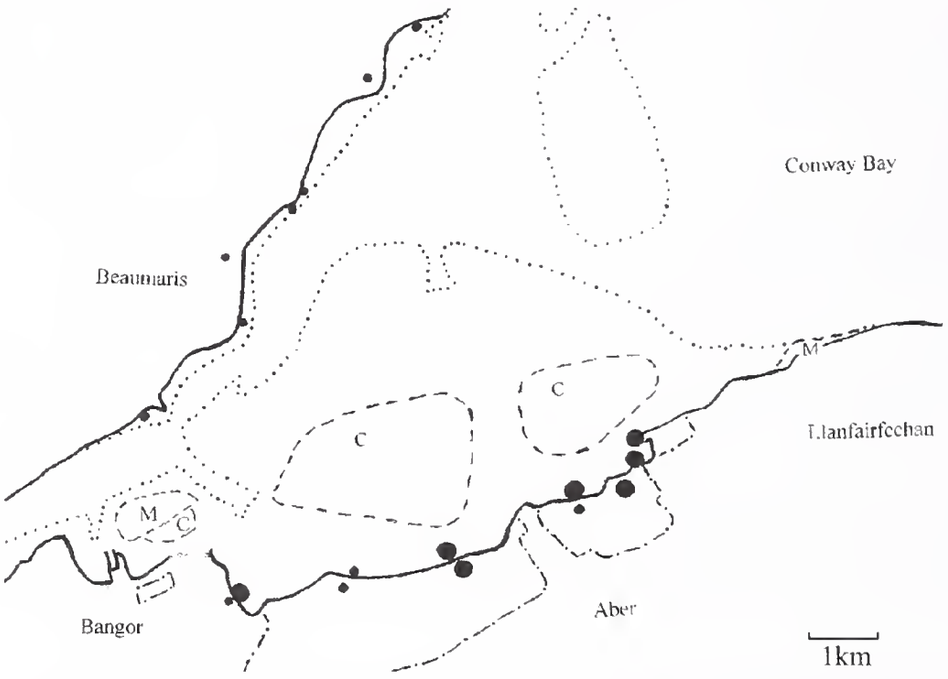

Figure 1. Sketch map of Traeth Lafan showing Oystercatcher roosts and main feeding areas during the study. *Large filled circles denote regular roosts of >1,000 birds, small circles <1,000 birds. Extreme low water mark indicated by dotted lines; main cockle (C) and mussel (M) feeding areas by dashed lines; terrestrial foraging sites by dash-dot lines.*

METHODS

Oystercatcher Population

From September 1964 to June 1969 Oystercatcher numbers were assessed mainly by monthly and supplementary counts either at roosts or of birds dispersed on feeding areas. The numbers feeding on each cockle and mussel ground were recorded separately as were their flight lines to the 5 main high-water roost sites.

Ringing and Colour Marking

Oystercatchers were caught, using either a single cannon net or clap net, at roosts along the eastern sector between Llanfairfechan and Aber. Roosts in the western sector were either inaccessible or mixed with other waders. Birds were aged as juvenile (first-year), older immature (2 or 3 years old) or adult (>3 years) using criteria comparable with later BTO methodology (Prater et al., 1977). A total of 824 Oystercatchers was ringed between March 1963 and December 1968, of which 586 (all except the first and last catches) were also colour-banded. The numbers ringed included: 42 in March 1963, 273 in August-November 1964, 232 in September-October 1966, 81 in June 1967, and 104 in December 1968. The 1964 colour-bands were made from soft but durable PVC electrical tubing, split then fastened with stainless steel staples to form 'leg flags'. Birds were marked with area and catch (date) codes. All 1966-67 birds were given individually recognisable triple codes - of rigid 'darvic' PVC split rings on one leg, and a soft PVC catch code plus the metal ring on the other leg. These 313 uniquely marked birds were then studied for nearly three years, from autumn 1966 until spring 1969, when the project was foreclosed. Those observations form the basis of this analysis of site fidelity among Oystercatchers.

Observational and analytical procedures

(a) Autumn 1964 marked birds:
To estimate the numbers remaining at Traeth Lafan during the first winter after marking, and returning in subsequent years, numerous sub-samples of the population were examined each month to measure the proportions of marked to unmarked birds present. An overall estimate of the percentage frequency of marked birds each month was then obtained for each sub-area and occasion by aggregating data samples. Finally, actual numbers of marked birds were estimated in relation to the total population counts.

(b) 1966-67 triple-coded individuals:
To assess their overall abundance frequent observations were made both at pre-roost assemblies and on feeding grounds. Total numbers present from each of the three catches were estimated from catch codes as for, and alongside, the 1964 birds. The primary aim, however, was to identify all individuals from each catch known to be present each month together with their local movements and feeding preferences. Resultant numbers from the two methods were then compared for each month.

Observational efforts on triple-coded birds at Traeth Lafan from 21.9.66 until 31.3.69 amounted to 224 visits averaging 8.7 per month during August-March and 4.1/month during April-July. Of these, 72% were to the Llanfairfechan sub-area, and 28% to the western sector from Aber to Bangor Flats. Observations were made on 75% of all 10-day periods, with 81% cover during autumn to early spring and 58% cover in late spring and early summer, when only a residual population remained. No observations could be made during 18.11.67 - 23.12.67 due largely to foot-&-mouth disease access restrictions. Effort was reduced in winter 1968/69, by 10-20 visits, due to new work commitments.

The extent of any dispersal of birds from Traeth Lafan to other sites in north Wales was assessed from inspections of Oystercatcher flocks feeding on mussel beds at Conwy (37) and Rhos Point

(~10) to the east, and by other observers at Beaumaris (many dates) and other sites around Anglesey. Occasional observations were made at major wintering haunts further afield: mainly in the Dee Estuary and Morecambe Bay to the north-east, and Burry Inlet in south Wales.

The large amount of sightings and location records generated were plotted by 10-day periods, initially on unwieldy A3 gridded paper, in unsatisfactory attempts to display and analyse patterns of occurrence at Traeth Lafan. Latterly, the raw data could be transferred onto Microsoft Excel spreadsheets for easy display and interpretation.

RESULTS

Oystercatcher population

From autumn 1964 until June 1969 the annual peak counts varied between 2,500 and 4,500 birds, being lowest in the first three winters and showing a large increase in winter 1968/69 (Figure 2). The peak month was September in the first three years, followed by steady declines through winter, whereas in 1968/69 numbers continued to rise through early winter to a January peak. A further increase occurred in the 1969/70 winter to a peak of 6,100 in January. Thereafter, until 1974/75 at least, wintering numbers continued to be high, averaging 5,200 for December and January counts with winter peaks ranging between 4,650 and 5,850 birds. An over-summering residual population of 450-575 non-breeders was present each June except for high counts in 1970 (~1,000) and 1971 (1,175), these perhaps reflecting one or two recent good breeding seasons. These birds were predominantly in immature plumages but also included a few apparent adults in full breeding plumage.

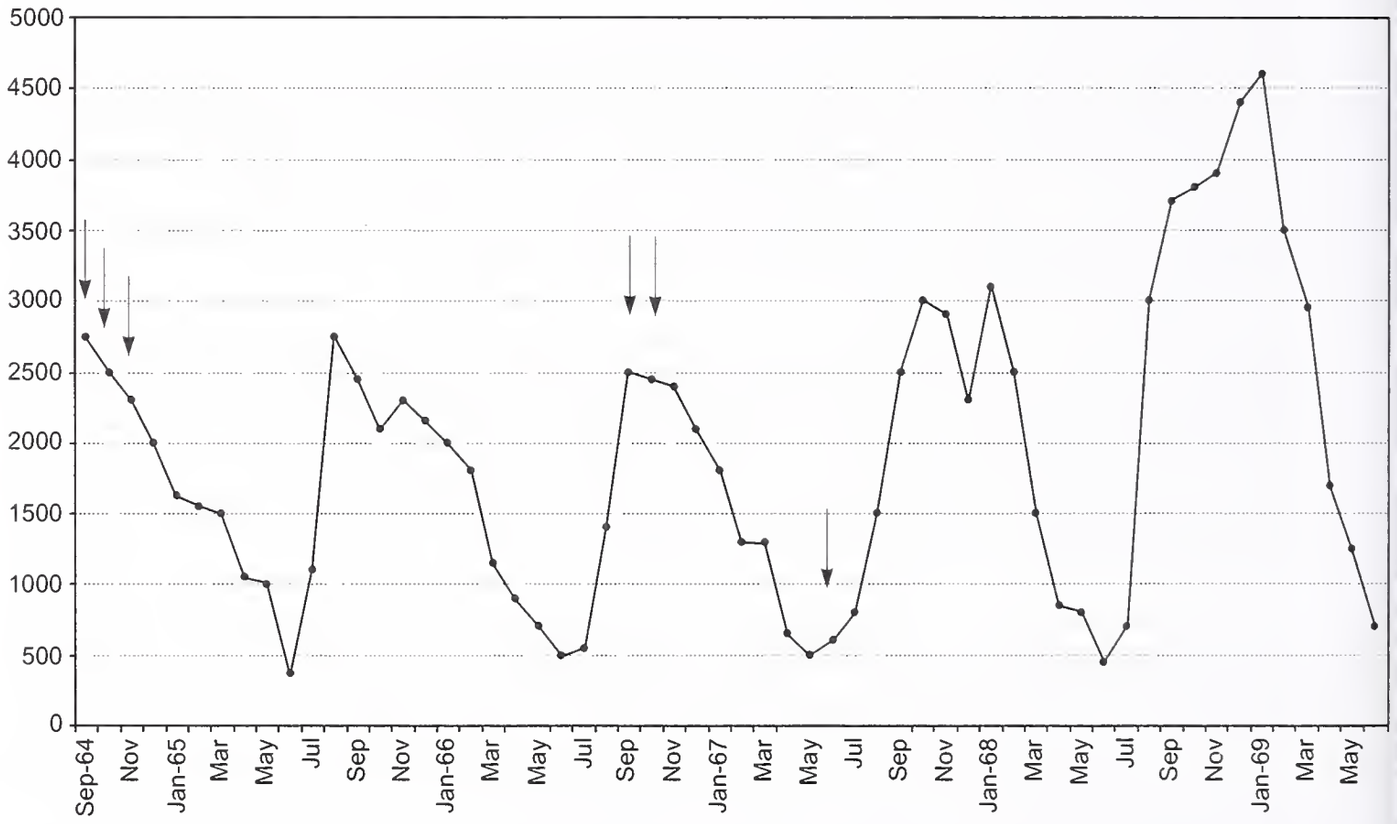

Figure 2. Numbers of Oystercatchers at Traeth Lafan during 1964-69. *Arrows denote when catches were made for the ringing and colour-banding study.*

First returns of post-breeding adults, and occasional juveniles, were noted from early August onwards. First spring departures of adults were observed on February 15th (1970) when, typically in clear late afternoon conditions, a small group left the roost after high water and headed out to sea climbing away high northwards with excited calls until lost to telescope view.

Most Oystercatchers foraged across the sand flat cockle grounds; and 300-400 (maximum 515) regularly fed through each winter on mussels at Llanfairfechan and 500-600 on the wild mussel beds at Bangor. Thus, between-winters differences in total population size were due largely to variations in the numbers of cockle feeders. Fewer than 100 birds foraged in the upshore muddy zone for worms and the two small clams *Macoma balthica* and *Scrobicularia plana*. During very wet and/or windy conditions in winter several hundred birds often foraged by day for earthworms and insects in the pastures immediately behind the shore. Predation on trial plots of farmed mussels at Bangor was first observed in winter 1968-69 when 400-500 birds fed there. Later, in autumn 1974, up to 1,100 birds were taking young mussels from the first large relaid bed near Bangor harbour.

Origins of the Oystercatcher population

Traeth Lafan is located on the west coast flyway for Oystercatchers migrating to and from northern breeding grounds and southerly wintering areas in Wales, south-west England and beyond (Dare 1970). Ringing results showed that the breeding grounds covered a wide geographical span of northern countries. Thus, 65 ringed or colour-banded birds were either recovered (59) or seen (6) in breeding habitats in: Norway (3, one at the Arctic Circle), Iceland (3), Faeroe Isles (16), Scotland (38, both coastal and far inland), northern England (2), Anglesey (2) and Dee Estuary (1). A further 15 birds marked on breeding grounds as adults or pulli were recorded at Traeth Lafan: Fair Isle (4), Isle of Man (1) and Anglesey (10). Another 8 birds were recovered when apparently on passage to or from breeding areas: Denmark (1), The Wash (2) and Scotland (5).

During winter and passage periods Traeth Lafan marked birds were recorded from various estuaries and bays along eastern coasts of the Irish Sea. The 51 recoveries or retraps came from Isle of Man (2), Morecambe Bay (2), Dee Estuary (4), N.Wales (13, 11 on Anglesey) and Burry Inlet (2). Colour-banded birds were seen in these estuaries (up until 1970) as follows: Morecambe Bay (5), Dee Estuary (8, 12 and 15 in successive winters), Conwy Estuary (7-10 each winter), Burry Inlet (13, 5, and 9 in successive winters) and Anglesey (5, excluding Beaumaris sector, see later). At Traeth Lafan itself 27 birds had been recovered dead (to 1999) and at least 40 were retrapped there between 1973-99 by a later ringing group (SCAN and Cambrian Ornithological Society reports, 1973-2002). The last bird to be recovered was found dead on 14.2.03 within 1 km of the ringing site. It had been ringed as an immature in June 1967 and was 37.5 years old, a national record.

Further evidence of movements between Traeth Lafan and other sites was provided by recoveries and sightings here during 1963-70 of birds colour-banded elsewhere by the MAFF projects in: Morecambe Bay (2 retraps, 1-3 seen each autumn or winter for 6 years), Dee Estuary (8 dead, 12-23 birds seen each autumn or winter 1963-69), Burry Inlet (10 differently coded birds seen over 5 winters) and Exe Estuary (single sightings in August and April).

Site fidelity of autumn 1964 marked birds

The 272 birds colour-banded with simple catch codes at Llanfairfechan roosts, between August 13th and November 21st, comprised on average ~4% of the Traeth Lafan population at the times of ringing. Their combined age composition was: 212 adults (77.9%), 56 immatures (20.6%)

and only 4 juveniles (1.5%); a fairly typical age structure among Oystercatchers netted here and elsewhere (MAFF data). Subsequently, there was a consistently higher proportion of these birds each year in the flocks of Llanfairfechan sector than in Aber sector 1-5 km to the west. There was limited mixing; many birds tended to remain faithful to a limited range within Traeth Lafan. The extremes of mean monthly frequency (%) values during each August-March period, 1964/65 to 1968/69, were:

Llanfairfechan	7-9	5-9	2-6	2-5	1-2
Aber	2-4	1-3	1-3	~1	~0.5

Figure 3 shows the estimated total numbers present at Traeth Lafan each month during the subsequent years to June 1969. As expected, there was an annual cycle of abundance broadly synchronous with that of the population (Figure 2) while returning numbers declined steadily over time. There was a rapid decrease in the first months after marking such that approximately only one third were still found at Traeth Lafan by mid-winter. In the following year 1965/66 numbers of returning birds peaked in early autumn then fell sharply throughout autumn and winter. This pattern suggests that most of the marked birds were indeed on passage south when captured and marked or had used Traeth Lafan prior to dispersing to other localities. The average numbers present in successive mid-winters (December-January) fell steadily, by ~ 40%, over the five years from ~75 birds in 1964/65 to ~45 in 1968/69. A few birds were still over-summering up to three years later.

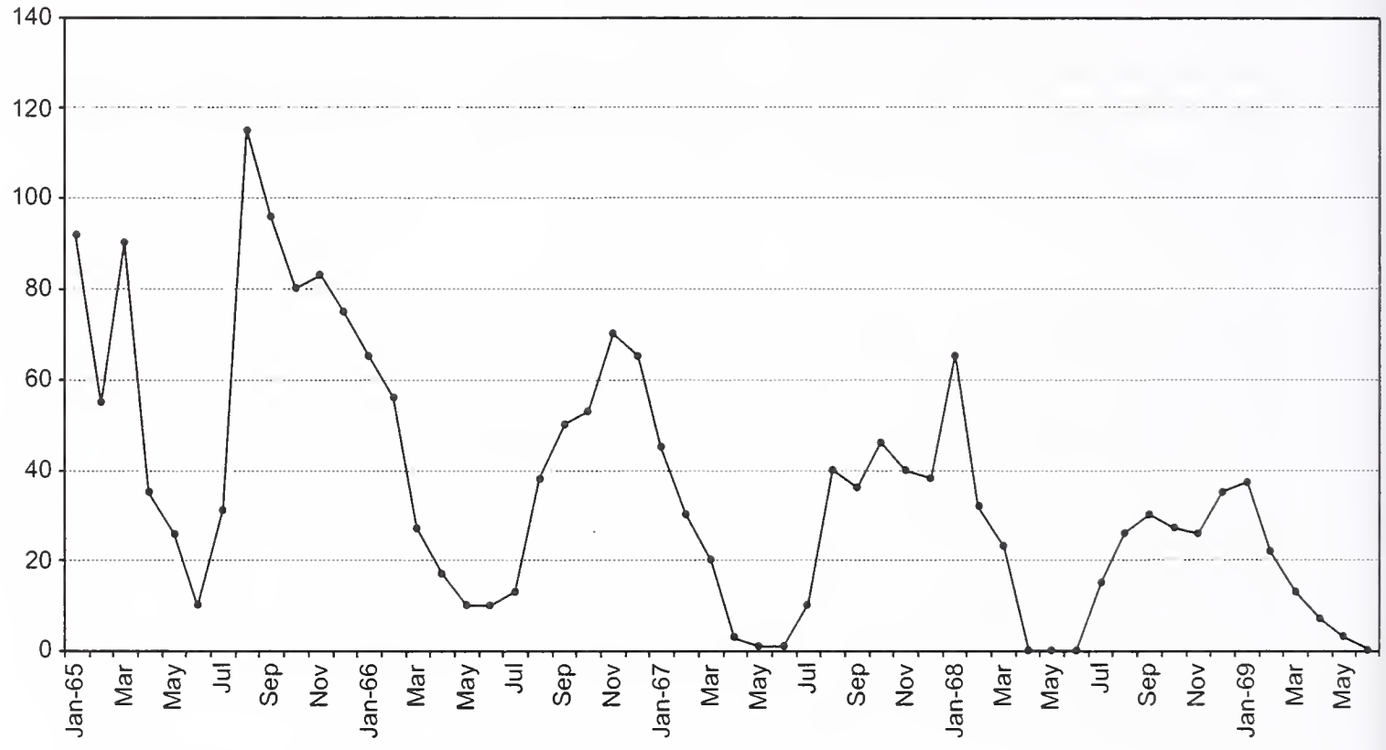

Figure 3. Estimated numbers of the 272 Oystercatchers that were catch colour-banded in autumn 1964 and observed again at Traeth Lafan each month up to June 1969.

Some of the 'missing' birds were located elsewhere in north Wales and further afield. During the 1964/65 winter, birds were seen on Anglesey (several often at Beaumaris and 3 elsewhere), up to 7 regularly at the Conwy mussel beds, 4 at the Rhos Point mussel bed, 6-10 in the Dee Estuary in November, and up to 13 on the Burry Inlet cockle beds in February. A similar scatter was noted in the next autumn/winter when principal counts were at Conwy (8 in August), Dee Estuary (12-20 in October) and Burry Inlet (5 in January) as well as at Morecambe Bay (4 in October). Further sightings were made over the next two winters in some of these estuaries.

Site fidelity of autumn 1966 triple-coded birds

The 232 birds individually marked at Llanfairfechan roosts, on September 20-21st and October 5th, represented ~9 % of the total Traeth Lafan population at that time. Their combined age composition was: 185 adults (79.7%), 42 immatures (18.1%) and 5 juveniles (2.2%); very similar to that of the autumn 1964 catches. Also as before, these birds subsequently formed a higher percentage of the flocks in Llanfairfechan sector than in Aber sector. The range of mean monthly frequencies (%) during each August-March period, 1966/67 to 1968/69, were:

Llanfairfechan	5.5-7.8	3.3-4.4	2.4-3.3
Aber	3.2-3.6	1.9-3.3	2.0-2.3

Figure 4 shows the estimated total numbers of marked birds present at Traeth Lafan each month, up to June 1969, plotted separately for the two methods. There was good agreement between the two series until 1968/69 when estimates based on individually identifiable birds were consistently and markedly lower than those using the standard catch code. By then, slippage and/or partial loss of hard darvic rings prevented positive identification of some birds. Confirmation of deteriorating rings was obtained from birds retrapped in December 1968 on which the darvic was becoming thin and fragile. Nonetheless, two codes were still intact after 9 years, in September 1975.

The seasonal and annual patterns of (re)occurrence of triple-coded birds were very similar to those of the 1964 experiment (Figure 3) and, as before, they followed the population cycles (Figure2). Both methods showed that most of the 1966 marked birds moved rapidly away during that autumn while about one third (80) were present at each census in winter 1966/67 and again in winter 1967/68. Similar numbers of re-occurring birds in winter 1968/69 were indicated by the catch code frequencies; but fewer triple-coded birds were identified for reasons given above.

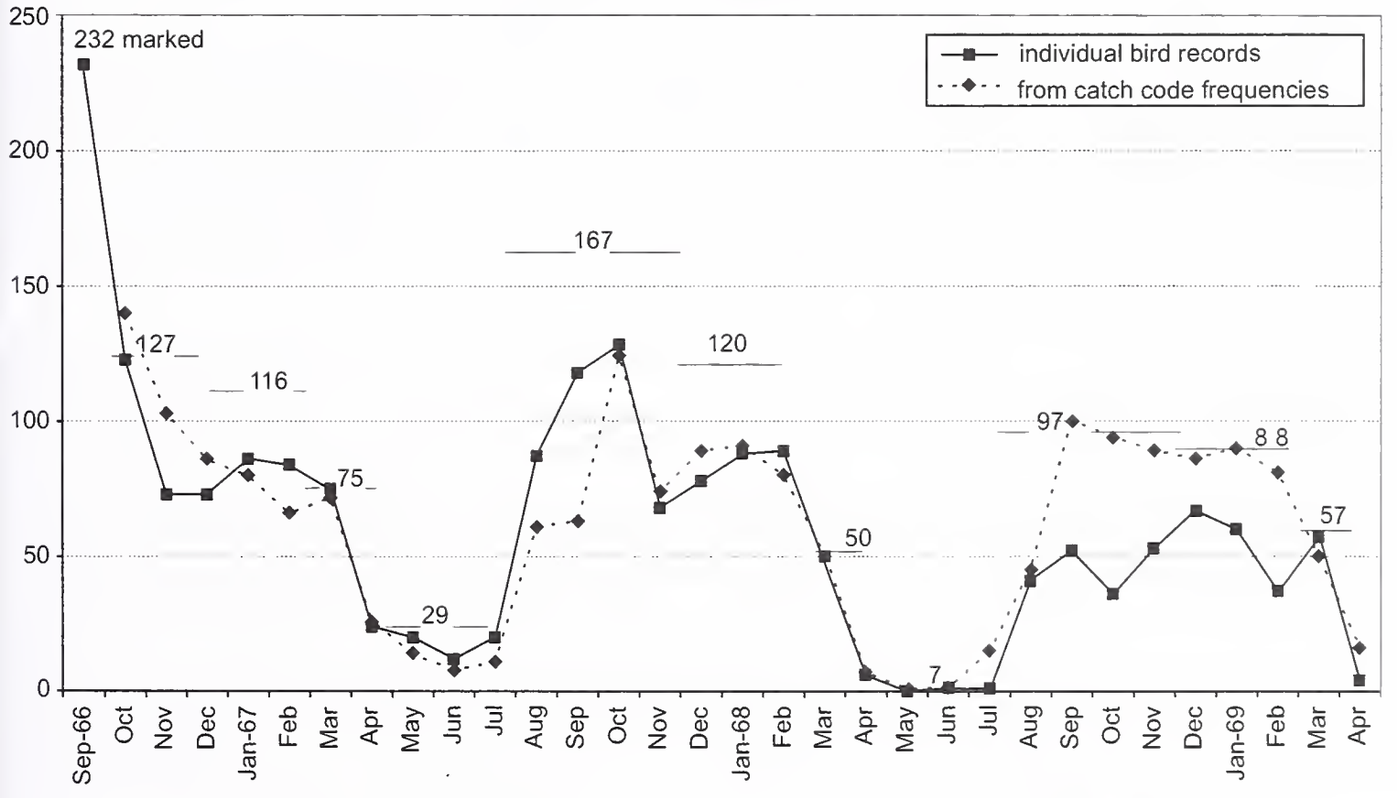

Figure 4. Numbers of individually colour-coded Oystercatchers from 232 marked in September-October 1966 and observed again at Traeth Lafan up to April 1969. *Estimated by two methods: (a) individual codes observed (continuous line), (b) from frequencies of their catch codes in flocks (dashed lines). Horizontal bars with numbers denote totals of individuals identified in each season.*

However, analyses of the sequence of sightings dates for each triple-code, as displayed on spreadsheets, showed that more birds actually were utilising Traeth Lafan during each 3-month period (season) than were being indicated by the monthly data. For example, during the 1966/67 winter 116 individuals (50%) were recognised (Figure 4, horizontal bars) whereas only 76-85 of these were seen in any particular month. A similar total (120 or 52%) was identified there in winter 1967/68 and at least 88 (38%) in 1968/69. Many of these were the same individuals returning for the winter. This within-winter pattern of occurrence suggests that some birds made intermittent foraging excursions from Traeth Lafan to other feeding sites nearby. In autumn, 179 birds (77.2%) were seen again here in 1967 and 121 (52.2%) in 1968, many apparently being on passage.

Limited searches over the three winters located 12 of the 'missing' birds feeding at: Rhos Point (3), Conwy (1), Beaumaris (6, some resident), Red Wharf Bay (1) and Merioneth (1). During winter 1966/67 none was observed in either the Dee Estuary (4,240 birds examined) or Burry Inlet (137,700 examined).

Site fidelity of June 1967 triple-coded individuals

The 81 over-summering birds marked on June 14th represented ~ 15% of the population at that time (Figure 2) and, as expected, virtually all were immatures. There were 38 first-summers (just under a year old), 34 two or three year olds, and 9 adults in breeding plumage. Subsequent sightings showed that, unlike those from autumn catches, these birds were twice as frequent in the larger Aber sector flocks than in the smaller flocks at Llanfairfechan. Mean percent frequencies (with ranges) during the 1967/68 and 1968/69 August-March periods were:

Llanfairfechan	0.6 (0.5-0.8)	0.5 (0.4-0.5)
Aber	1.2 (0.9-1.7)	0.9 (0.8-1.1)

Figure 5 shows the total numbers of individuals recognised in successive seasonal periods (horizontal bars) rather than in each month's samples. A substantial proportion of these birds remained (or reoccurred) at Traeth Lafan until March 1969. Most (86%) were still present during autumn 1967 but fewer (44%) stayed in winter 1967/68. Thereafter, 48% again over-summered before numbers fell slowly to 31% in the 1968/69 winter. Searches elsewhere located one bird feeding in Cymyran Bay, Anglesey, in December 1967 while a bird seen on Burry Inlet cockle beds in September 1968 and February 1969 had presumably wintered there.

The age at which 33 of these immature Oystercatchers first acquired full adult breeding plumage was determined directly by frequent observations. These showed that the final moult, in late winter and/or early spring, often transformed a bird's appearance over 1-2 months. There was a spread of ages at which birds became fully adult. Of 13 first-year individuals (1966 year-class), 4 moulted to breeding plumage in February/March 1969, when 2.75 years old, but stayed on site through that breeding season. The other 9 were still in immature plumage in March/April 1969, and would not have moulted before early 1970 when they would have been ~3.75 years old; based on a mean 'birth' (fledging) date of July 1st. Likewise, among 20 of the older immatures (born 1965 and 1964) 5 acquired breeding plumage during March-June 1968 (at nearly 3 years minimum age) and remained, 6 did so in spring 1969 (at 3.75 yma) but 9 not before 1970 (~4.75 yma).

Individual patterns of fidelity

There was great variability in the extent to which individually recognisable birds remained at or returned to Traeth Lafan in the next few years. A small proportion of each catch was never seen again - 8.6% of autumn 1966 and 6.2% of June 1967 birds. Others were seldom seen after the

first 2 months while a few others reappeared briefly a year or more later. Some birds were seen annually during passage periods only. In contrast, a substantial contingent of birds reappeared each autumn to then over-winter at Traeth Lafan; many of these remained faithful to particular feeding and roost sites. Thus, of the 91 adults seen there in the first winter after marking, 67 (74%) were seen again next winter, and of those 42 (63%) were noted the following winter as well. The last value was minimal largely due to reduced observation effort and some damage to colour rings. Evidence of long-term fidelity or reoccurrence subsequently came from birds retrapped at the same roosts by the SCAN Ringing Group. Several ringed between 1963-66 were recaptured after 10-19 years while four others recaught in the early 1990s were at least 20-27 years old. Of 1967 triple-coded birds 13.6 % were still being found here 13 years later and an exceptional bird was found dead after 36 years, as noted previously.

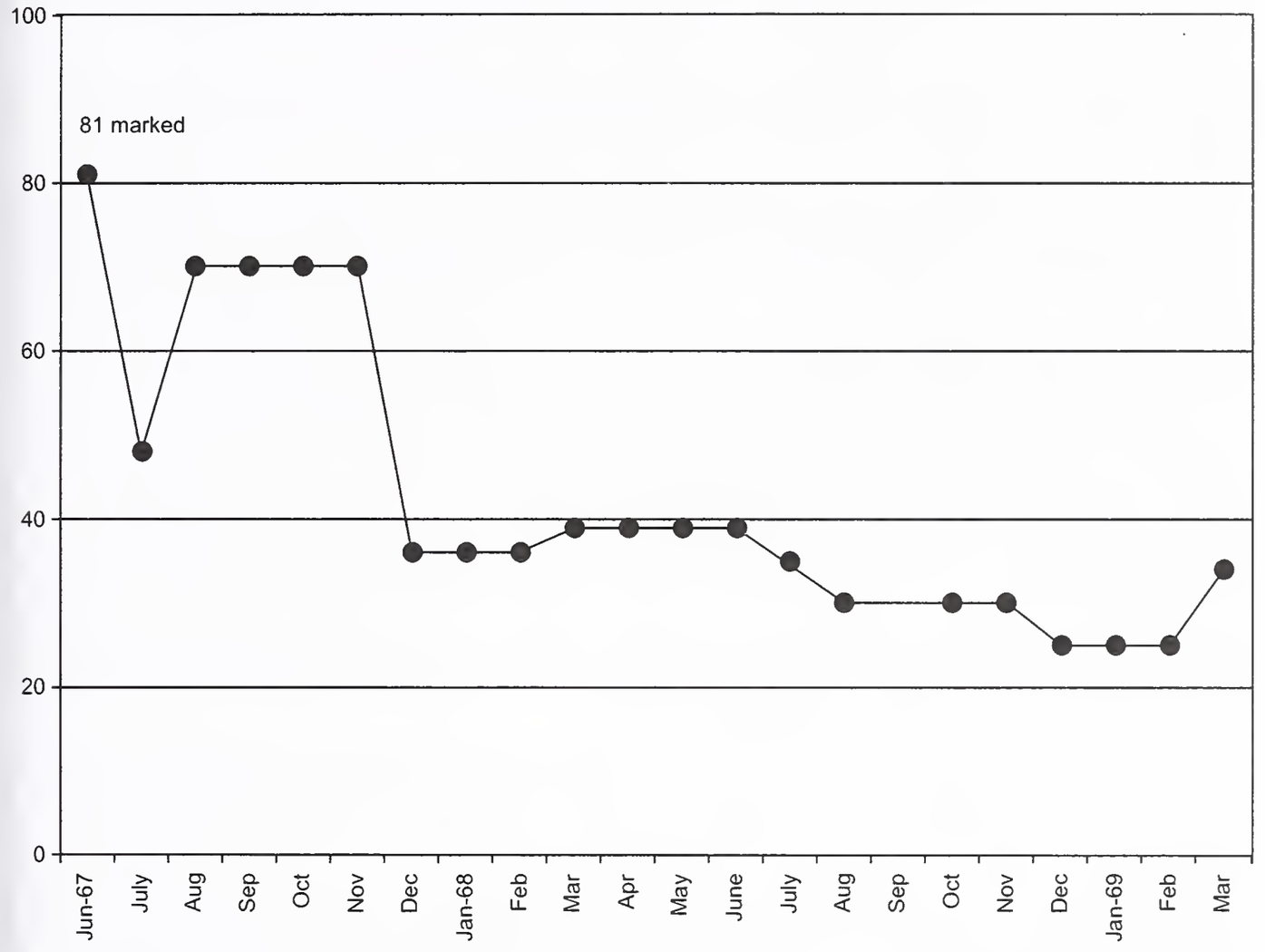

Figure 5. Numbers of individually colour-coded Oystercatchers from 81 marked in June 1967 and observed again at Traeth Lafan up to March 1969. *The horizontal bars show the total number of individuals identified in each period, and are linked to indicate the overall trend.*

Prey preferences

From all the triple-coded 1966-67 catches, 201 (64 %) individuals later were observed feeding. Similar proportions fed on mussels and cockles. There were 75 (37.5 %) exclusively mussel feeders, 9 (4.5 %) predominantly mussel feeders, 87 (43 %) exclusively cockle feeders, 27 (13.5 %) 'mixed' mussel/cockle feeders, but only 3 (1.5 %) foraged in the muddy clam and worm zone. These records included some first-year immatures. Thus, of the 5 juveniles marked in autumn 1966, three were noted taking mussels, and two also cockles, that winter. Of the 38 first-

year birds marked in June 1967, 7 were later seen to be mussel-feeders, 13 cockle-feeders, 3 ate both foods, and one was taking *Scrobicularia* clams.

DISCUSSION

This Traeth Lafan study, as other contemporary MAFF research on Oystercatchers in Wales and elsewhere (e.g. Dare 1966, 1970, Davidson 1967), preceded the era of national estuarine birds counts that started in 1969/70 (Prater 1981) as well as the mass netting and ringing (except in the Wash) of waders that are such familiar activities today. Moreover, colour-banding of waders, and especially the use of codes enabling individual recognition, had not been attempted on a large scale; suitable colour-fast and durable materials had still to be found and tested in the demanding estuarine environments.

Population size and age structure

The overall trend towards increasing Oystercatcher numbers in winter between 1964-69 (Figure 2) was sustained until 1970-74 at least (see above). To what extent this represented a recovery from depletion of both cockles and Oystercatchers by the very severe 1962/63 winter is not known. In the earlier years of the MAFF study numbers had peaked in autumn and fallen sharply throughout winter. The increases (1964-69) were mainly of cockle-feeders, the major component of the population, whereas the numbers of mussel-feeders changed little between winters. The upward trend suggests natural increases in local food supplies, particularly of cockles, or shortages elsewhere. After the 1962/63 winter, it took many years for cockle stocks in Morecambe Bay to recover sufficiently to support a viable fishery again. There are no data on the size of Traeth Lafan cockle stocks at this time, but there is anecdotal information that on westerly coasts of Wales the freezing conditions did not deplete cockles as severely as in the eastern Irish Sea estuaries. The wild mussel stock then on Bangor Flats, though of no commercial value, was estimated at ~8,000 tons gross biomass in 1959, showed little change in the 1960s (MAFF surveys, G.Davies, pers. comm.). However, the annual fraction accessible to Oystercatchers was not determined. The first predation upon farmed mussels at Bangor occurred in 1968/69 and again in 1974; since when large-scale intertidal cultivation has developed that doubtless has attracted more birds.

The predominance of adult Oystercatchers, a scarcity of juveniles but a substantial fraction of older (2-3 year) immatures at Traeth Lafan from autumn to spring are characteristic of populations in other major estuaries around the British Isles (Dare & Mercer 1974, Goss-Custard *et al.* 1982a). Similar proportions of all immature ages combined (juveniles and 2-3 year olds) were found in autumn at Traeth Lafan during 1983-2000 by the SCAN Ringing Group (Atkinson *et al.*, 2005a, b). These features reflect, in part, this wader's high longevity, deferred maturity (to 3 or even 4 years) and often low annual breeding productivity (Cramp & Simmons 1983, Blomert *et al.*, 1996). Nevertheless, juveniles clearly were under-represented in autumn catches when their largest numbers would have been expected. One explanation is that most juveniles may be excluded from or avoid major cockle and mussel feeding flocks through inability to compete with dominant older birds while the youngsters are perfecting the specialised techniques needed to feed on hard-shelled bivalves (Goss-Custard *et al.*, 1982b, Durell et al., 1996a). Instead, they can forage efficiently on mudflats for 'soft' prey such as marine worms (Durell *et al.*, 1996b) and for small clams, and may also explore 'poorer quality' sites elsewhere. For example, in 1969 a group scavenged with Turnstones from piles of dead (opened) mussels discarded on the upper shore beside the factory then operating at Bangor. In addition, some British-bred juveniles are missed because they migrate in their first autumn to western France and Iberian coasts (Dare 1970, Wernham *et al.*, 2002).

Wintering site fidelity

The original MAFF programme showed that Oystercatchers marked in five major west coast estuaries were more likely to be recorded, dead or alive between September-March, in the same estuary where each had been ringed than in the other sites (Dare 1970). There were limited exchanges between these estuaries. Such fidelity to specific passage/wintering sites is now known, of course, to be a widespread behaviour not only among Oystercatchers but also for many Holarctic wader species and other groups of migratory breeding birds. However, only by use of individual colour coding could the extent of fidelity by particular Oystercatchers be investigated.

The follow-up (1966-69) study at Traeth Lafan provided much detailed information on movements of individual Oystercatchers within and between given autumn-spring periods, and sometimes almost on daily or weekly time scales. The overall impression was of constant flux or turn-over within the population, this (as expected) being greatest during passage months, much less in mid-winter and least through May-June when a residual flock of immatures remained. Nonetheless, a substantial number of birds displayed a high degree of fidelity to Traeth Lafan by returning to spend at least part of successive winters here. Of these, a notable core confined themselves to a very small area at Llanfairfechan where they commuted daily between roosts and a nearby mussel bed feeding site. Similar degrees of fidelity have been recorded since among mussel-feeding Oystercatchers in the Exe Estuary (Goss-Custard *et al.*, 1982a, 1982b). There, 85-92% of adults that spent one winter were likely to return and be seen again in the next. The proportions of 'faithful' juveniles and older immatures were also high, at 76-89%. The Exe adult values were higher than those for Traeth Lafan birds for several reasons. Firstly, the Exe is at the southern end of the west coast flyway for adult Oystercatchers whereas Traeth Lafan is also a stop-over point for many birds in autumn en route to winter haunts in South Wales and south-west England (Dare 1970, Wernham *et al.*, 2002). Secondly, observer effort (by an ITE team) was much greater in the Exe, and the later type of darvic colour rings used there proved more durable.

Some cockle-feeders in the Aber sector behaved similarly, though observations here on the exposed sands were more limited due to greater dependence upon a favourable combination of tidal and weather conditions. Other wintering Oystercatchers made excursions intermittently to alternative feeding areas along the north Wales coast.

Feeding considerations

Oystercatchers are renowned exploiters of hard-shelled intertidal molluscs, most notably of mussels and cockles, and adults typically display individual preferences and skills for tackling particular prey species (reviews in Goss-Custard 1996). However, they are also versatile predators. In the Wadden Sea, as their food supplies change seasonally, individuals must switch between 3-4 prey species in winter to obtain their daily food requirements (Zwarts *et al.*, 1996). Individual Oystercatchers at Traeth Lafan also showed strong feeding preferences; 81% of triple-coded birds were seen feeding either only on mussels or only on cockles though 13% ate both species. During the 1960s, when Oystercatcher winter numbers rose steadily at this site, there were no large changes to mussel stocks in the Menai Strait and no indications of a major natural perturbation in cockle abundance in the same area. However, the latter species is well known for major fluctuations in recruitment and there was a long period with very poor recruitment at this time in eastern Irish Sea estuaries, notably the Dee, Ribble and Morecambe Bay. This period of relative stability with low cockle stocks contrasts with events in the 1980-90s when several large, if short-lived, falls in Oystercatcher winter numbers were attributed to three winter episodes of mechanised cockle harvesting (Atkinson *et al.*, 2005a, b), apparently responding to higher stock levels and increased market demand. In this recent period major

cockle recruitments in the Dee, Ribble and Morecambe Bay had revitalised those fisheries. At Traeth Lafan, however, other decreases in Oystercatchers that had either preceded or happened well after fishing was stopped were probably responses to natural fluctuations in cockle availability. The lowest population size in 1980-90s winters approximated that recorded during 1964-67 (fig. 2). By 2000-02, Oystercatchers on Traeth Lafan had increased to record levels, with peaks of 7-8,000 birds. These rates of increase were much faster than could be predicted from positive changes in breeding success and survival rates. This suggests that many newcomers were taking advantage of the new artificial food resource provided by the mussel lays at Bangor. The extent to which local cockle-feeding birds also may have moved onto farmed mussels is not known. The findings from the 1960s MAFF and other studies suggest that many Oystercatchers would have responded to temporary cockle stock depletion in the past at Traeth Lafan by wintering elsewhere on the west coast flyway, such as the Dee Estuary and Burry Inlet, until cockle abundance had recovered.

The Traeth Lafan study revealed complex patterns of individual behaviour and mobility of Oystercatchers within the flocks utilising Traeth Lafan even during a period when food supplies remained undisturbed by fishing activities. Indeed, this population should be regarded as a small component of a large and flexible 'meta-population' of Oystercatchers dispersed around the shores of Liverpool Bay. The more recent cockle fishing events show the need for site managers to gather regular and more reliable information on cockle stock abundance at Traeth Lafan and the extent to which farmed mussels might be accessible to, and exploited by, Oystercatchers during autumn and winter. The study reported here should provide some basis for a better understanding of the potential or observed effects of any future fishery exploitation of Traeth Lafan cockles.

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THE POPULATION STATUS AND HATCHING SUCCESS OF CURLEWS *Numenius arquata* IN WALES IN 2006

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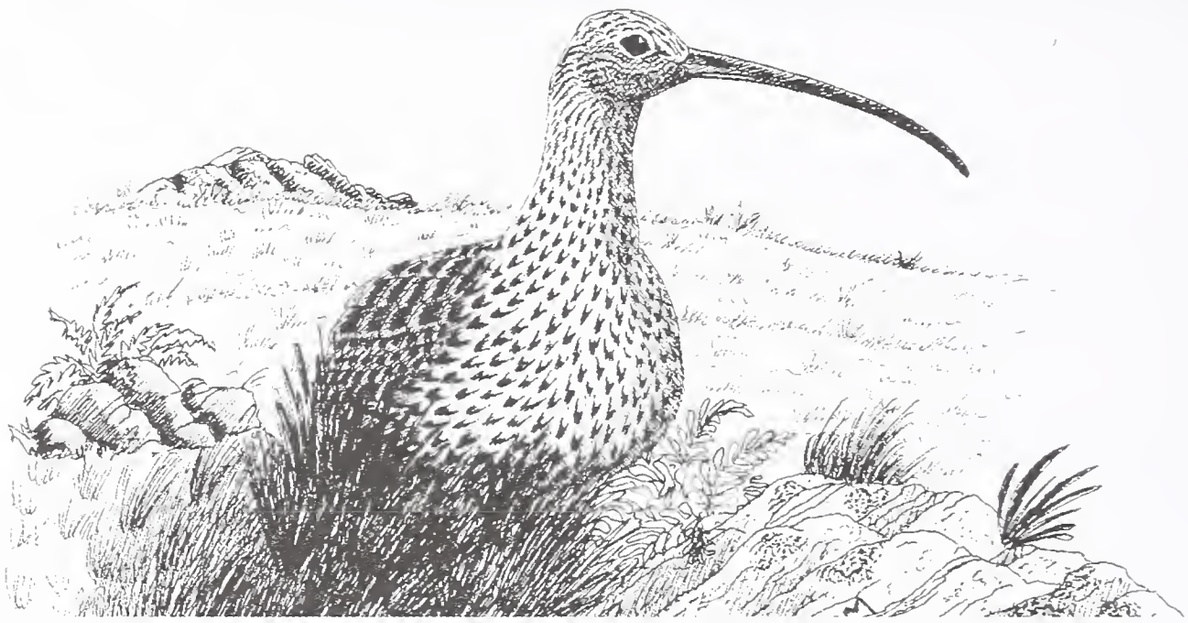

SUMMARY

1. Periodic surveys and annual monitoring suggest breeding Curlews have drastically declined in Wales in recent decades, prompting the Welsh Assembly Government to publish a Biodiversity Action Plan (BAP) setting out conservation objectives and targets. The aim of this survey was to complete the first objective in this by revising the estimate of population size.
2. Some studies elsewhere suggest population growth is limited by breeding success. Data on hatching success will indicate if this is possible in Wales, and obtaining these was an additional aim.
3. Results showed there were 1,099 Curlew pairs in 2006 (95% confidence limits 576-1755), a significant decline since last surveyed in 1993. This evidence for decline compares favourably with other surveys. Just 14% of occupied squares had broods, although the sample size was small.
4. Between 1993 and 2006, squares were abandoned independently of geographic location, altitude and how much of each was moorland, suggesting the influence of large-scale processes such as agricultural change. Low breeding success is a plausible explanation for the observed population decline.
5. Curlew nest at low densities, and few sites hold significant numbers. The best course to meet the Wales BAP target of restoring the 1993 population by 2020 is to increase breeding success through positive management of nature reserves that have current or recent records of breeding Curlews, and a tailored and targeted package of agri-environment options elsewhere.

INTRODUCTION

Since the 19th century, there have been considerable changes in Curlew breeding numbers and distribution within Wales (Lovegrove *et al* 1994). From the 1920s, there was an increase in breeding range from their previous strongholds on upland moors and bogs to enclosed pasture along river valleys and on coastal lowland. However, numbers have declined over the past three decades, including the uplands (table 1). Indeed, there is evidence from lowland wet grassland that Curlews declined faster than Lapwing *Vanellus vanellus* in Wales between 1982 and 2002 (-75% vs. -69%, Wilson *et al* 2005). Although restricted to one habitat, this is the only repeat survey that has covered both species.

Table 1. Surveys, re-surveys and annual monitoring of Curlews in Wales. Surveys not based on full or sample coverage of specific regions or habitats are excluded.

Year	Region /Habitat	Design	Sample size	Breeding pairs	Density (pairs -km²)	Reference
1981-85 & 2002	Upland	Sample of sites	17 sites (97.4km²)	179 to 31	1.84 to 0.32	Sim *et al (2006)*
1982 & 2002	Lowland wet grassland	Sample of sites	65 sites (115 km²)	100 to 25	0.87 to 0.22	Wlson *et al* (2005)
1986	Anglesey	Full coverage	762km²	408	0.54	Seddon & Bellamy (1988)
1986-87	Montgomery	Full coverage	1950km²	247	0.13	McFadzean & Tyler (1987)
1993	All Wales	Random sample of 1km sqrs, single stratum	170 1km sqrs	10,763	0.52	O'Brien *et al* (1998)
1993	All Wales	Reanalysis of O'Brien *et al* (1998)	170 1km sqrs	5,713	0.27	Appendix of this study
1994-2005	Breeding Bird Survey	Stratified sample of 1km squares	269 1km sqrs in 2005	-[1]	-[1]	Raven *et al* (2006)
2006	All Wales	Random sample of 1km sqrs, single stratum	331 1km sqrs	1,099	0.05	This study

[1] The Breeding Bird Survey calculates an index of change over time and cannot provide information on numbers or density of breeding pairs.

The population status of Curlew has been assessed. It is amber-listed at the UK-level because ≥20% of regional breeding and wintering populations use the UK, and its' European status is unfavourable (Gregory *et al* 2002). In Wales, however, Curlew is red-listed because of its rapid decline (>50% in breeding population over previous 25 years: Thorpe & Young 2002). The Welsh Assembly Government has named Curlew as a 'species of principal importance for the conservation of biological diversity', with conservation objectives and targets set out in a BAP.

Revising the estimate of population size is the first objective of the BAP. Studies of some declining Curlew populations suggest growth is limited by breeding success (e.g. Grant *et al* 1999). Data on this are lacking for Wales, and would help identify whether conservation management should be focussed on this life-stage. Therefore, the aim of this survey was to estimate the breeding population size and hatching success of Curlew in Wales.

METHODS

Survey design

For a survey to be useful, it must achieve adequate accuracy and precision: confidence in the result depends on this. Accuracy cannot easily be assessed directly (Gregory *et al* 2004). Precision, however, can be determined by the sample size, the number of birds found in the sample and their degree of aggregation between sample units, and is usually expressed as 95% confidence limits. In addition to estimating population size, surveys can also detect change over time, but this is only possible if the same sampling approach and field method as a previous survey are repeated, so accuracy is comparable. For declining species, however, precision will be poorer for a given sample size if a survey is repeated. In Wales, the Curlew population size was first estimated by a sample survey in 1993. Since then, abundance indices and habitat-specific surveys have indicated a decline. Therefore, the 2006 survey was designed as a repeat of the 1993 survey, augmented by additional sample units to achieve adequate precision.

The required sample size was determined by simulation. First, the 1993 survey data were reanalysed using the current method of interpreting Curlew survey data. This was because the original estimate was thought to be too high (Green 2002), and an improved and validated method is now available (Grant *et al* 2000). Applying this calibration (maximum count on visits 1-3 multiplied by 0.71 with 0.1 added for each site where Curlew were recorded) produced a population size of 5,713 pairs. This compares poorly with 10,763 (based on maximum number of 'pairs' on visits 1-3) but is much closer to the figure of 6,360 (mean number of 'pairs' in May and June), both from O'Brien *et al* (1998). Second, growth rates calculated using Welsh data from the only two repeat surveys of Curlew were used to predict the range of population sizes expected in 2006 (a population is declining when its' growth rate <1)(table 2). Third, new survey data for 2006 were simulated by reducing the calibrated number of Curlew pairs in each 1km square visited in 1993 by the best and worse-case growth rates over the 1993-2006 period based on these growth rates (52% and 71% respectively).

Table 2. The Curlew population sizes predicted in Wales in 2006. These are based on a population size of 5,713 pairs in 1993 and estimates of growth rate calculated for Welsh data from the two repeat Curlew surveys. A population is declining if its growth rate <1

Repeated Survey	Years	Annual growth rate	Predicted Welsh population (prs)
Waders of wet meadows (Wilson *et al* 2005)	1982 & 2002	0.94	2738
Repeat upland bird survey (Sim *et al* 2006)	1981-85 & 2002	0.91	1676

These two sets of simulated data were used to create further data sets from n=50 to n=300 in increments of 50. Each sample size was created by random re-sampling with replacement, and confidence limits around each population estimate calculated by bootstrapping. To do this, further random re-sampling with replacement was used to create 999 different population estimates. Precision was taken as the 95% confidence limits of this set of estimates. Sample size was considered adequate when a) the upper confidence limit was less than the 1993 population estimate (evidence of a significant difference) and b) confidence limits were about

30% of the simulated 2006 population estimate for both best and worst case growth rates. The first of these was achieved for n> 150. The second was only approached (35%) when n>300, and this was taken as the required minimum sample size. In 1993, 170 1km squares were visited (stratum 1); therefore, 200 new squares were selected to achieve adequate precision in 2006 (stratum 2), allowing for some in each strata where visits prove not possible.

Field methods

Field methods repeated those of O'Brien *et al* (1998) but took into account those of Grant *et al* (2000). Three visits were made approximately every three weeks. The dates for visits 1-3 were: 17th April - 7th May, 8th May - 28th May and 29th May - 18th June. Successive visits were made at least a week apart. At least one of visits 1-3 was made during the three hours after sunrise or three hours before sunset, repeating O'Brien *et al* (1998). Counts did not take place during very wet or windy conditions. Not all habitats are suitable for breeding waders. Unsuitable habitat within squares was defined as woodland, built areas and steep slopes, and these areas were not surveyed during visits. A small number of squares (6%) contained >50% of unsuitable habitat, particularly conifer plantations, and these squares were not visited. Data were recorded on maps and recording forms on a field by field basis. Curlews flying over squares without landing were excluded as they may have been breeding elsewhere. Flocks of Curlew (>2) were recorded separately from breeding birds, as they probably contained non- or failed breeders. Systematic recording of habitat and its' management did not take place.

Additional visits can be used to estimate hatching success (Grant *et al* 2000). The number of Curlew singles or pairs alarm calling, indicating the presence of chicks, was recorded during visit 3, with two further visits (visit-4: 19th June - 2nd July and visit-5: 3rd July - 16th July) being made to those squares with earlier Curlew records.

Analytical methods

To calculate confidence limits for the completed stratified survey, 999 population estimates were created separately for each stratum. Each pair of estimates was then summed across the two strata, with precision being expressed as the 95% confidence limits of this combined set of estimates. This was the same method as O'Brien *et al* (1998) ensuring confidence limits were comparable between the two surveys.

RESULTS

Survey coverage

Of the 370 1km squares selected, 331 were visited (90%). Other than unsuitable habitat, lack of time was the main reason that squares were not visited. Visits were within the specified periods on 91 % of occasions (7% were early and 2% late). All squares received visits 1-2, but not all received visit 3 (table 3), although all squares with records during visits 1 or 2 did receive a third visit. Of 49 squares with zero counts on visits 1 and 2 that received visit 3, none had any Curlew records. This was evidence that, in cases where third visits did not take place, the total counts of Curlew at this time could be assumed zero in calculations of numbers of breeding pairs, and all 331 squares could be included calculating the population estimate. One or more of visits 1-3 were within three hours of dawn or dusk for two thirds of squares. Most squares where this did not happen were upland (altitude >200m). Some counts (<10%) did take place in marginal weather conditions due to the need to complete visit rounds within the correct periods.

Of the 331 1km squares visited, suitable habitat was not fully surveyed in 30 (9.4%), representing just 1.4% of the 331km^2 area. Only one of these squares had Curlew records. The total area of each stratum was reduced by the area of suitable habitat not surveyed in calculations of population size.

Similarly, not all squares with Curlew records received visits 3-5 required to estimate hatching success (table 3). No alarm-calling birds were recorded during visit 3 to the 66 squares with Curlew records. However, alarm calling was recorded in two of the 14 squares that received visit 4. Therefore, because there may have been broods in squares that were not visited four times, hatching success was calculated using this sub-sample of 14 to minimise the risk of underestimation. No alarm calling was recorded on the four squares that received visit 5, which included those with earlier alarm calling. The other 10 squares with no alarm calling by July (period for visit 5) were assumed unproductive, as the previous visit had had no Curlew records.

Table 3. Numbers of squares surveyed and numbers of visits to the two strata of randomly selected 1km squares in Wales in 2006

Strata	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5
Stratum 1 (repeated from 1993)	148	148	34	8	3
Stratum 2 (new in 2006)	183	183	33	6	2
Total	331	331	67	14	5

Population size

The results for squares in each bird recording area and stratum are shown in table 4. Each stratum was considered to have sampled half the 20,972km^2 (O'Brien *et al* 1998) area of Wales. Therefore, the population estimate was the product of the Curlew density in each sample and the area of each stratum, summed across the two strata following Gregory *et al* (2004). Its' precision was estimated by bootstrapping. There were 1,099 breeding pairs of Curlew in Wales in 2006 (95% confidence limits 576-1,755), indicating a decline of 81% since 1993 based on the revised estimate of 5,713 (see appendix). Density had fallen from 0.27 to 0.05 pairs km^{-2}. No flocks of non-breeding birds were encountered during visits 1-3: the visits used to estimate population size (table 4).

Table 4. Curlew survey coverage and number of pairs and broods found (after calibration of data from multiple visits), by sample strata and bird recording areas (old vice counties). Note that applying the calibration of Grant *et al* (2000) often results in non-whole numbers.

	Stratum 1 (repeated from 1993)			Stratum 2 (new in 2006)			Combined		
County	Sqrs	Pairs	Broods	Sqrs	Pairs	Broods	Sqrs	Pairs	Broods
Anglesey	4	1.28	0	8	0	0	12	1.28	0
Brecon	14	0.34	0	21	0	0	45	0.34	0
Caernarfon	11	1.05	0	7	0	0	19	1.05	0
Carmarthen	15	0.57	0	24	0	0	39	0.57	0
Ceredigion	13	0.34	0	9	0	0	22	0.34	0
Denbigh	17	2.23	0	14	2.9	2.22	31	5.13	2.22
Flint	3	0	0	2	0.34	0	5	0.34	0
Glamorgan	13	1.15	1.06	18	0	0	31	1.15	1.06
Gwent	1	0	0	13	0	0	14	0	0
Meirionnydd	14	0	0	15	0	0	29	0	0
Montgomery	18	3.79	0	20	0.67	0	38	4.46	0
Pembroke	9	0	0	18	0	0	27	0	0
Radnor	16	0.57	0	14	1.28	0	30	1.86	0
Total	148	11.31	1.06	183	5.2	2.22	331	16.51	3.28

Although twice as many pairs were found in stratum 1, the probability of a survey square being occupied did not differ between strata (binary logit model χ^2_1=2.000 P=0.1573), suggesting that Curlews have not simply redistributed themselves away from the squares surveyed in 1993.

Change in occupancy between surveys

Comparing the occupancy of squares visited in both 1993 and 2006 shows there were declines in all but one bird recording area (Anglesey, table 5), with squares in three areas having lost their Curlew (Flint, Meirionnydd and Gwent). Squares in Pembrokeshire continued to contain no Curlew.

Table 5. Change in the number of Curlew breeding pairs in squares surveyed in 1993 and 2006 by bird recording area

County	No sqrs	1993	2006	% change
Anglesey	4	1.15	1.28	11.92
Caernarfon	14	1.62	1.05	-35.39
Denbigh	11	4.66	2.23	-52.15
Flint	15	0.34	0.00	-100.00
Ceredigion	13	1.25	0.34	-72.99
Meirionnydd	17	5.74	0.00	-100.00
Montgomery	3	12.36	3.79	-69.36
Radnor	13	4.76	0.57	-87.96
Brecon	1	4.42	0.34	-92.39
Carmarthen	14	2.97	0.57	-80.67
Glamorgan	18	1.86	1.15	-38.24
Gwent	9	0.81	0.00	-100.00
Pembroke	16	0.00	0.00	0.00
Total	148	41.93	11.31	-73.02

This variation in the decline across Wales provides an opportunity to test for associations between change in square occupancy and the following likely explanatory variables: easting, northing, mean altitude of each square and how much of each square was moorland (unenclosed). This was done using logistic regression with the dependent variable being the occupation (=1) or abandonment (=0) by Curlew between 1993 and 2006. Eleven squares were occupied (9 retained 2 gained) while 34 were abandoned. The maximal model was simplified by removing the least significant interactions and then main effects in turn, until only significant terms remained. There were no significant effects at the 5% probability level.

Hatching success

Just two (14%) of the 14 occupied squares with adequate visits showed evidence of chicks being hatched (tables 4& 6). However, because of the small sample size, this result may be inaccurate and should be treated cautiously.

DISCUSSION

Accuracy and precision

Estimates of population size, and extent of decline from re-surveys, can lack accuracy and precision if the design of a repeat survey differs from the original, if the sample size is too low or if the field methods are not carried out properly. In this case, additional survey squares were selected in the same way as previously; the sample size met the requirement; the field methods

were the same; and the majority of visits to squares were within the specified periods. Although visit 3 for some squares with no earlier records did not take place, evidence suggests this had no impact on the estimated numbers of pairs present. However, some waders are often more active and detectable in early morning and late evening (Reed *et al* 1985) and the method specified at least one visit to squares at either of these times. It is possible that some birds in squares without early or late visits were not detected, leading to an underestimate of population size and overestimate of the extent of decline. However, health and safety requirements restricted visits at these times for the more remote squares. Furthermore, this timing is consistent with the widely used Brown & Shepard (1993) survey method for waders in upland areas (visit times 08:30- 18:00), and the high detectability of displaying Curlew means the results should not be influenced greatly.

Confidence limits were 43% of the population estimate. This is less precise than in 1993 (28%), but adequate to demonstrate a statistically significant decline. However, if the decline continues unchecked, a future resurvey to revise the population size again may be impractical, given the likely sample size needed to achieve even this precision.

Extent of decline

With an annual growth rate of 0.88 since 1993 (95% confidence limits 0.84- 0.92), this resurvey highlights the rapid decline in Curlew across all habitats in Wales. The direction of this across-habitat population trend is consistent with those measured by recent habitat specific lowland and upland resurveys (table 1), although rates of decline were less severe (table 2). One explanation for this is that many sites covered by these surveys were already designated as protected areas with breeding bird assemblages as features, and have received a degree of sympathetic management for many years. More severe declines in breeding Curlew in the wider countryside are to be expected.

The direction of trend suggested by 2006 resurvey is also consistent with the BTO/RSPB/JNCC Breeding Bird Survey (BBS). However, the annual growth rate of 0.94 from the BBS suggests half the rate of decline (95% confidence limits 0.91 to 0.98). One reason for this may be that the BBS method assigns records to three distance bands and uses differences in counts between these to correct abundance estimates for the lower detectability of birds further from the transect line. Records of calling birds are not excluded, and the outer distance band is unlimited (Raven & Noble 2006). So, although records of flocks and birds in flight are not included in analyses, Curlews heard calling from outside the square under survey are not explicitly excluded. Calling Curlews are easily heard over distances of >1km when populations are at low densities, and measures were taken to exclude birds not breeding in focal squares in the 2006 survey. Given that over two thirds of Curlew records from the BBS method fall in the outer distance-band, it is possible that volunteers carrying out the BBS are unconsciously biasing their data towards distant records outside the survey square as birds become scarcer. Indeed, BBS squares are currently around three times as likely to report Curlew than the 2006 Curlew survey squares (14% vs. 5%). Nevertheless, the confidence limits of the per annum declines from the 2006 survey and the BBS do marginally overlap, and sampling error may still explain much of the discrepancy.

Correlates of decline between surveys

Curlews were lost from squares independently of their geographic location, altitude or extent of unenclosed moorland within squares, and supports the results of other resurveys that also found declines in quite different habitats (table 1). These results together suggest a process or processes operating at large spatial-scales and over long periods. For example, the economic pressure to intensify agriculture that has existed in recent decades. Although change in agriculture in Wales since 1993 has probably been less marked following the introduction of

agri-environment schemes, the Curlew population may still be responding to changes in demographics, such as reduced breeding success, brought about by widespread agricultural intensification in the 1970s and 1980s. Mechanisms linking agriculture to low breeding success are likely to include nest and chick loss through trampling by livestock (Grant 1997), and field operations (Berg 1994). In Wales, this is more likely to be repeated silage mowing than cropping. There is also evidence that Curlew populations are limited by predation in some areas of the UK (Grant 1997, Grant *et al* 1999). Predators, such as Carrion Crows *Corvus corone* (Gregory & Marchant 1995) have increased in Wales and southwest England in recent decades. However, interactions between the effects of predators and land management on breeding success can be complex, and predator control alone cannot be assumed the best conservation management option without good evidence.

Warmer springs are known to have advanced the timing of breeding and the availability of their invertebrate prey in another wader, the Golden Plover *Pluvialis apricaria* (Pearce-Higgins *et al* 2005). Changes in environment conditions may similarly influence Curlew ecology, although there is no evidence that this is a contributory factor in the current decline.

Does observed breeding success explain the population trend?
Because so few Curlews were found and not all of visits 3-5 were completed, estimating the percentage of pairs hatching chicks was considered unreliable due to the small sample size. Although expressing results as the percentage of occupied squares with evidence of chicks hatching is probably more reliable (Grant *et al* 2000), the estimate of hatching success for 2006 should still be treated cautiously. Breeding success also varies between years due to differences in weather. An estimate based on several years would be more reliable.

Population trends are determined by demographic rates such as breeding success and survival. For Curlew, previous studies have identified low breeding success as a factor limiting population growth (e.g. Grant *et al* 1999). The breeding success (chicks fledged per pair) needed to explain an observed decline can be calculated using estimates of annual survival and recruitment age. However, hatching success (broods per pair or per occupied site) based on alarm calling cannot be translated into breeding success (chicks fledged per pair). Nevertheless, some conclusions about the observed hatching success can be made by comparison with previous studies where both hatching success and breeding success were measured (table 6). Hatching success in 2006 was lower than in most other studies.

Assuming the same survival and recruitment values as Grant *et al* (1999) (adult survival of 0.88, first year survival of 0.5-0.65 and recruitment to the breeding population at three years old), breeding success (chicks fledged per female) would need to be 0.21-0.27 chicks per pair to achieve the observed population decline, based on a deterministic population model (one in which all individuals perform the same each year). This is within the range of other studies (table 6), but around half the 0.48 chicks per pair suggested for population stability in Northern Ireland (Grant *et al* 1999). Whilst also relatively low, the hatching success measured in Wales cannot be translated into breeding success, and intensive studies would be needed to confirm that breeding success is this low in Wales. Nevertheless, it seems highly plausible that Curlews in Wales are currently unable to fledge enough chicks to replace the mortality of adults. Indeed, the lack of non-breeding birds would support this, with lack of recruits rather than lack of habitat in which nesting can be attempted being the most limiting factor. Most Curlew breeding in Wales winter on the coast further west and south in the UK and northwest Europe (Wernham *et al* 2002). Wintering numbers in the UK are stable (Maclean *et al* 2005), and there is no evidence to suggest that adult survival has declined.

Table 6. Hatching success based on survey visits 3-5, and breeding success based on intensive studies, compared between data in Grant (1997), table 7 of Grant *et al* (1999), table 1 of Grant *et al* (2000) and Wales in 2006. Breeding success to explain change in the Welsh population was modelled as 0.21-0.27 chicks per pair.

Study area	Habitat	No. occupied sites or survey squares with visits 3-5	% Sites with chicks based on visits 3-5	Mean & range of breeding success (chicks/pair)
Haweswater	Upland rough grass	6	67	-
North Pennines	Upland rough grass	5	40	0.60 (0.59 - 0.61)
Lough Erne	Lowland wet grass	6	33	0.36 (0.20 - 0.56)
Wales	Random 1km sqrs	14	14	-
Antrim	Upland rough grass	7	0	0.19 (0.14 - 0.26)

Conclusions

By estimating population size, this survey has met the first objective of the Wales Curlew BAP. These and previous results highlight the rapid decline of Curlews in recent decades across a range of habitats throughout Wales. Inadequate breeding success seems the likely proximate cause of this decline, and candidate ultimate causes have been suggested.

Because they breed at such low densities, few sites hold important numbers. Breeding pairs also show strong site fidelity (Berg 1994). Conservation management for Curlews on nature reserves with current or recent records should be a priority. In addition, and as set out in the BAP, the main mechanism for their conservation outside nature reserves must be agri-environment schemes, such as Tir Gofal. Schemes should aim to deliver: 1) critical breeding-season conditions, in the form of nest sites, accessible food and low losses to predators; 2) targeted at or near remaining occupied sites and 3) in sufficient quantity and quality to improve breeding success enough to halt or reverse the current decline. Schemes are only likely to be effective if all these aims are delivered. Although some existing options meet some of these aims, there are currently no option-packages that meet all of them.

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SHORT NOTES

NIGHTJAR *Caprimulgus europaeus* RESEARCH IN MID AND SOUTH WALES

This short note summarises the important findings of a collaborative research project between Tony Cross, Jerry Lewis, the Brecknock Wildlife Trust and the Forestry Commission in 2004 and 2005, with match funding from the Countryside Council for Wales Species Challenge Fund.

A recent increase in the number of Nightjars nesting in Wales, to their highest recorded level, has been brought about by the birds moving into commercial forestry plantations which, through the cycle of planting and felling, have created large areas of suitable breeding habitat. The occupation of clear-felled forestry by Nightjars in Wales has, somewhat atypically, occurred predominantly in the uplands.

In the present study four distinct Nightjar populations, with a total of 35 territorial males, were studied in 4113 hectares of managed conifer forests in Brechfa, Crychan, Glasfynydd and Mynydd Du Forests. Nightjar nests in conifer plantations are normally very difficult to locate through a combination of relatively low breeding density , difficult terrain and the often large homogenous areas of suitable habitat. The thirteen nests located in this study therefore provided some otherwise scarce data on breeding characteristics in this habitat.

It was found that the majority of nesting Nightjars selected clearfells in the four to nine years age-range (69%) with extreme cases of one pair nesting in an area of clearfell that had been felled for less than twelve months and not yet replanted and another pair which moved to a small clearing in a 19 year old re-planting for their second brood (the area was wet and boggy so the trees hadn't grown well and there were gaps between the trees). Defining a clearing as the total contiguous area felled in the same year the minimum clearing size recorded was five hectares and the mean was twenty three hectares. All the nests located were in the altitudinal range of 290-380 metres, although the study sites ranged from 100 metres up to 700 metres; this was probably due to the fact that the majority of the suitable habitat was within this narrow range. Nest sites were principally on flat ground, either on plateau areas or flat-bottomed cwms (only two of the thirteen were on slopes greater than 1 in 10). Two confirmed and three probable cases of double broods were identified, a much higher figure than found in earlier detailed studies in Suffolk, suggesting good quality habitat and food supply in the Welsh study area.

The observed density of 35 territorial male Nightjars was between 0.52 and 1.59 per square kilometre of forest (all age classes combined). The lower densities were, not surprisingly, in the areas of forest with the lowest percentage of clearfell less than thirteen years old. The amount of suitable habitat per territorial male, defined as all open areas plus areas planted less than thirteen years before the survey year, was much more consistent between sites and ranged from 28.4 to 53.4 hectares.

A number of individual birds were caught and fitted with radio transmitters as part of the study. Results showed that foraging activities peaked for an hour or two after dusk and an hour or so before dawn. The majority of foraging, particularly when providing for chicks, appeared to be in areas in close proximity to the nest, usually in open areas within the forest itself. Radio-tracked Nightjars left the forest for periods up to six hours when they were not breeding or had large young in the nest, but radio-tracking failed to identify distant foraging areas and habitats used.

The key findings of this research are to be incorporated into a series of management plan objectives for upland managed forests in the United Kingdom. In this respect the issue of the importance of clear-felled forestry to Nightjars for both nesting and feeding, and in particular the minimum size of clear-felled compartments, is highly pertinent. The Wales Woodland Strategy target is to increase the total area of the public forest estate managed under continuous cover systems or LISS (Low Intensity Sylviculture System) to 50%. This could have a marked negative effect on Nightjar populations in Wales if the wrong areas were to be selected for LISS.

WELSH BIRDS

'Welsh Birds' is the journal of the Welsh Ornithological Society and is published twice a year, in June and December. The December issue is primarily devoted to the Welsh Bird Report and the annual report on Bird Ringing in Wales.

Papers for 'Welsh Birds' are welcomed by the Editor on any aspect of Welsh ornithology. The Society is anxious that the journal should accurately reflect present ornithological activity in Wales. Thus we hope that all workers, professional or amateur, with results of bird studies in Wales, will always consider publishing information about these here. All papers will be reviewed by the Editor and an independent referee. Authors should follow the format of papers published in the journal and guidelines for authors have been drawn up and are available from the Editor (address in side front cover). Papers are accepted and published in either Welsh or English. In accordance with standard international practice papers in Welsh should be supplied with captions to tables and figures in both Welsh and English and with an English summary.

Short notes on interesting or unusual features of behaviour recorded in Wales are also welcomed. An accumulation of such items is of considerable value. Notes should be short and succinct, ideally of not more than half a page in length. Notes may also be submitted in either Welsh or English.

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